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SOME STATISTICAL ASPECTS OF SOIL FERTILITY FIELD EXPERIMENTS [1]

AMADOR D. YÑIGUEZ

A great number of fertilizer experiments have been conducted on various crops by agricultural experiment stations and agencies and by commercial agricultural enterprises. The results of some of these experiments have been used directly for fertilizer recommendations. However, with experience accumulated through the years, it has become increasingly apparent that the conditions of the individual farmer's field must be taken into account when making such recommendations. The Extension Service, or other agencies concerned with making the major portion of detailed fertilizer recommendations to farmers, generally utilize such information. Characterization of the individual farmer's fields may either be qualitative or quantitative. Qualitative information generally requested is soil type, past cropping history and past fertilization and liming history. Quantitative information is obtained in the form of soil tests for the common plant nutrients and lime requirements.

Thus the current prevailing practice in making fertilizer recommendations to a farmer or producer of a particular crop in a particular field is to use all available research information from field experiments to judge the nature of expected crop response in the light of the qualitative and quantitative information gathered on that particular field.

Results of fertilizer experiments from different locations are often combined to determine the response function. The responses, however, even if determined from data from a single locality, are not adjusted for the existing soil and climatic conditions. Soil and climatic conditions vary from location to location. The basic levels of available soil nutrients, for example, will vary from one locality to another. On the assumption that these basic levels increase the levels of the nutrient in the treatment applied, it is obvious that the response measured will be due not only to the effect of the applied nutrient (s), but to the effects of the applied plus the basic

[1] General Contribution No. 881. Based on a portion of the author's unpublished work entitled "Investigation of alternative models for utilization of measures of residual nutrients in soil fertility field experiments."

levels. Hence, in estimating the response the estimates will be biased by the presence of the available soil nutrients which vary within locations and from one location to another.

In any large investigation of the problem of estimating crop response to different types and varying combinations of fertilizer it is desirable to ensure that accurate results be obtained with as little work as possible. It is therefore preferable to take into account the nutrients available in the soil and make the necessary adjustments for these nutrients in the determination of the fertilizer response surfaces.

Anderson [2] discusses the biases incurred by neglecting the available soil nutrients when fertilizer response data from several locations are combined. For a quadratic prediction equation involving one nutrient:

$$E(x) = \beta_0 + \beta_1 x + \beta_{11} x^2$$

where x is the amount of nutrient added and $E(x)$ is the average predicted yield when x is applied. If the actual amount is taken into consideration, then the predicted yield $[E^*(N)]$ when x is applied is:

$$\begin{aligned} E^*(N)^{3} &= (\beta_0 - \beta_1\delta + \beta_{11}\delta^2) + (\beta_1 - 2\beta_{11}\delta)N + \beta_{11}N^2 \\ &= \beta_0^* + \beta_1^* N + \beta_{11} N^2, \end{aligned}$$

where δ is the available nutrient and N is the available plus the added nutrient $(N = \delta + x)$. If for a particular farm the available nutrient is $\delta_0 (N = x + \delta_0)$, then the predicted yield when x is added is:

$$\begin{aligned} E^*(x) &= (\beta_0 - \beta_1\delta + \beta_{11}\delta^2) + (\beta_1 - 2\beta_{11}\delta)(x + \delta_0) + \\ &\quad \beta_{11}(x + \delta_0)^2 \\ &= [\beta_0 - \beta_1(\delta - \delta_0) + \beta_{11}(\delta - \delta_0)^2] + \\ &\quad [\beta_1 - 2\beta_{11}(\delta - \delta_0)]x + \beta_{11}x^2. \end{aligned}$$

The bias in using $E(x)$ instead of $E^*(x)$ is

[2] R. L. Anderson, "Economic and Technical Analysis of Fertilizer Innovations and Resource Use," Iowa State College Press, Ames (1957).

[3] E* implies experimental value; E*(N), expected yield from nitrogen application.

$$E(x) - E^*(x) = (\delta - \delta_0)(\beta_1 + 2\beta_{11}x) - (\delta - \delta_0)^2\beta_{11}$$

Not only is the predicted yield biased, but the difference between the predicted yields for two different levels of farm application will also be biased. The bias in the difference between the predicted yield for an application of x_2 instead of x_1 is

$$2\beta_{11}(x_2 - x_1)(\delta - \delta_0)$$

which will be negative. One would then tend to underestimate the effect of added nutrients if the available nutrients at the farm are less than those at the experimental plots ($\delta_0 < \delta$).

The problems are aggravated more when one attempts to combine the results of experiments at two locations with different values of δ. Suppose for $\delta = \delta_1$ at one location and $\delta = \delta_2$ at a second location, ($\delta_2 > \delta_1$), but the same rates of application are used in each experiment; *e.g.*, $x = -1, 0, 1 \ldots$ If a quadratic model is used, the experimental model, $E^*(N)$, is:

$$E^*(N) = \beta_0^* + \beta_1^* N + \beta_{11}^* N^2;$$

where $N = \delta_1 + x$ at location 1 and $N = \delta_2 + x$ at location 2. Obviously the β's (regression coefficients based on x) will differ for the two locations, even though the β^*'s are the same.

In this case

$$E^{(1)}(x) = (\beta_0^* + \beta_1^*\delta_1 + \beta_{11}\delta_1^2) + (\beta_1^* + 2\beta_{11}\delta_1)x + \beta_{11}x^2$$
$$E^{(2)}(x) = (\beta_0^* + \beta_1^*\delta_2 + \beta_{11}\delta_2^2) + (\beta_1^* + 2\beta_{11}\delta_2)x + \beta_{11}x^2$$

where $E^{(1)}(x)$ and $E^{(2)}(x)$ are the average predicted yield, when x is applied, for location 1 and location 2, respectively. In other words,

$$\beta_0^{(1)} = \beta_0^* + \beta_1^*\delta_1 + \beta_{11}\delta_1^2; \quad \beta_0^{(2)} = \beta_0^* + \beta_1^*\delta_2 + \beta_{11}^*\delta_2^2$$
$$\beta_1^{(1)} = \beta_1^* + 2\beta_{11}\delta_1; \qquad \beta_1^{(2)} = \beta_1^* + 2\beta_{11}\delta_2$$

Hence,

$$\beta_0^{(2)} - \beta_0^{(1)} = \beta_1^*(\delta_2 - \delta_1) + \beta_{11}(\delta_2^2 - \delta_1^2);$$

$$\beta_1^{(2)} - \beta_1^{(1)} = 2\beta_{11}(\delta_2 - \delta_1).$$

If one averages the two regression equations, one obtains

$$\bar{\beta}_0 = \beta_0^* + \beta_1^*\left(\frac{\delta_1 + \delta_2}{2}\right) + \beta_{11}\left(\frac{\delta_1^2 + \delta_2^2}{2}\right)$$

$$\bar{\beta}_1 = \beta_1^* + 2\beta_{11}\frac{(\delta_1 + \delta_2)}{2}.$$

Hence, the average predicted increase due to adding x units of nutrient would be

$$\bar{\beta}_1 x + \beta_{11} x^2 .$$

This is the expected increase in yield only when the available nutrient is

$$\delta = \frac{\delta_1 + \delta_2}{2};$$

for all other values of δ, this is a biased predicted increase.

Even if the experimenter estimated β_0^* β_1^* and β_{11} for which each experiment would give unbiased results, and then averaged these estimates, he would obtain inefficient estimates. More efficient estimates could be obtained from a single analysis using the wider range of N: $(\delta_1 - 1)$ to $(\delta_2 + 1)$. This range is $2 + \delta_2 - \delta_1$, which is wider than the range of ± 2 at each location.

Adjustments should be made in setting up a model when the initial levels of the available soil nutrients are taken into account. Hurst and Mason [4] presented an adjustment for a particular soil-weather combination using a three-factor quadratic model on part of the data from the TVA-North Carolina cooperative project. The data they used were obtained from one type of soil (Norfolk), from six locations, for which the lack of fit mean square was negligible (table 1). For the three-factor quadratic, the model is:

$$E(Y) = \beta_{00} + \beta_{10}x_1 + \beta_{20}x_2 + \beta_{30}x_3 + \beta_{11}x_1^2 + \beta_{22}x_2^2 + \beta_{33}x_3^2 + \beta_{12}x_1x_2 + \beta_{13}x_1x_3 + \beta_{23}x_2x_3$$

[4] D. C. Hurst and D. D. Mason, "Economic and Technical Analysis of Fertilizer Innovations and Resource Use," Iowa State College Press, Ames (1957).

where x_1 is applied nitrogen (coded levels), x_2 is applied phosphorus (coded levels), and x_3 is applied potassium (coded levels). As pointed out above, the estimates β_{00} and β_{10} will vary from location to location if the available soil nutrient (δ_{11}) varies. Hence, if this model is used for different soil conditions, the estimates β_{00} and β_{10} should vary much more widely than predicted by theory. As shown in table 1, the estimates β_{00} and β_{10} were found by Hurst and Mason to fluctuate much too widely to be attributable to random variation alone, while the variation in β_{11} was not significantly different from expected.

Since all other results were as expected, it appears that δ_{2i} and δ_{3i} did not fluctuate materially from location to location. This rather suggests that one should use $N_1 = x_1 + \delta_1$ in the model and estimate β_0^* and β_{10}^* rather than β_0 and β_{10}: Then

$$\beta_0 = \beta_0^* + \beta_{10}^*\delta_1 + \beta_{11}\delta_1^2$$

and

$$\beta_{10} = \beta_{10}^* + 2\beta_{11}\delta_1$$

would vary for different values of δ_1. In this case β_0^* would represent the expected yield for $N_1 = 0$ and the other factor at their standard levels (when $x_2 = x_3 = 0$). Unfortunately the δ_1's are generally unknown; hence, some provision must be made to obtain estimates of them.

If one assumes that β_{00}^* is zero because there will be no yield when $N = 0$, then he can estimate β_{00}, β_{10} and β_{11} at each location and accordingly β_{10}^* and δ_1. At a given location, we use the model

$$E(Y) = \beta_{00} + \beta_{10}x_1 + \beta_{11}x_1^2 + (\text{remainder in } x_1, x_2, x_3).$$

Then we solve these two equations simultaneously to obtain β_{10}^* and δ_1;

$$\beta_{00} = (\beta_{10}^* + \delta_1\beta_{11})\delta_1; \beta_{10} = \beta_{10}^* + 2\beta_{11}\delta_1$$

$$\delta_1 = \frac{\beta_{10} + \sqrt{\beta_{10}^2 - 4\beta_{00}\beta_{11}}}{2\beta_{11}}$$

and

$$\beta_{10}^* = \sqrt{\beta_{10}^2 - 4\beta_{00}\beta_{11}}\ .$$

TABLE 1.—*Parameter estimates and their variances as estimated on 6 Norfolk-like soils*

PARAMETER	LOCATION NUMBER						OBSERVED $s^2(b_{ij})$	THEORETICAL $V(b_{ij})$	TEST x^2/n(5 d.f.)[a]
	51	52	53	55	57	58			
B_{00}	81.32	86.45	93.22	92.26	59.69	51.54	310.24	19.67	15.8 **
B_{10}	9.56	4.30	9.91	14.96	3.44	0.18	28.99	1.58	18.4 **
B_{20}	0.27	0.11	–1.14	1.98	1.08	–0.43	1.21	1.58	0.8 N.S.
B_{30}	–0.16	0.78	1.27	–0.71	–1.43	–2.10	1.66	1.58	1.1 N.S.
B_{11}	–8.00	–4.82	–7.57	–9.12	–6.01	–3.66	4.28	2.28	1.9 N.S.
B_{22}	–1.85	–0.58	–0.03	–1.41	1.09	–1.76	1.32	2.28	0.6 N.S.
B_{33}	–1.66	–0.92	–0.30	–0.80	0.65	–0.42	0.59	2.28	0.3 N.S.
B_{12}	1.18	–1.07	0.64	0.95	2.48	2.26	1.64	3.16	0.5 N.S.
B_{13}	1.17	–0.85	0.78	1.23	–1.377	0.85	3.83	3.16	1.2 N.S.
B	–0.95	–0.92	–0.51	–3.04	–1.14	–1.10	0.80	3.16	0.3 N.S.
M.S. error	100.12	104.17	89.11	91.58	117.63	104.44			
Av. MSE	101.18	(252 d.f.)							

Source: Hurst and Mason, "Some Statistical Aspects of the TVA–North Carolina Cooperative Project on Determination of Yield Response Surfaces for Corn," Chapter 18, *Fertilizer Innovations and Resource Use*, Iowa State College Press, Ames (1957).

[a] Values in this column should be multiplied by 5 in order to compare them with tabular values of x^2 (*i.e.*, these values are x^2/n).

As indicated above, this may give poorer estimates of β^*_{10} when averaged over all locations, as compared to a single estimation scheme based on all locations but with a different δ for each location.

The technique of multiple covariance can be used to assess and test the variability introduced by the initial soil nutrients. A covariance analysis on the available soil nutrients would provide information that may increase the accuracy of treatment comparisons. Information may be obtained by testing the error regression of the yield on the initial soil nutrients for significance. If the error regression is not significant it would mean that it would not be worthwhile to adjust for these initial soil nutrients in making treatment comparisons.

* * *

New information is the major goal of scientific research, and communication of information is vital for all scientific progress. However, the rapid, rather disordered growth of science has placed a severe strain on the channels of scientific communication.

—*I.A.C. Digest*

TREATMENT OF SWEET CORN SILKS WITH MALEIC HYDRAZIDE AND COLCHICINE AS MEANS OF INCREASING THE FREQUENCY OF MONOPLOIDS [1]

JOSE R. DEANON, JR.[2]

WITH TWO TEXT FIGURES

Maleic hydrazide (concentrations of 50, 100, 250, 500 and 1000 ppm) and colchicine (concentrations of 0.01, 0.05, 0.1 and 0.4 per cent) in aqueous solutions were applied to the silks of Golden Cross Bantam sweet corn 24 hours before pollination to determine their effects on the frequency of monoploids.

Kernel set and germinability were not affected by the treatments; however, there tended to be a decrease in kernel set in the butt region as concentrations of either maleic hydrazide or colchicine were increased.

The frequency of monoploids was significantly increased by the 50 ppm maleic hydrazide treatment. The colchicine treatment tended to decrease the frequency, but the differences were not significant. The frequency of monoploids in the check was 2.66 as contrasted with 6.96 per 1000 in the 50 ppm maleic hydrazide. The total population of seedlings screened for monoploids was 61,134.

Monoploid sporophytes, upon doubling of chromosomes, become homozygous diploids which may be of value to plant breeders because of the speed with which homozygosity is reached. However, the low frequency of spontaneously occurring monoploids has prevented their practical utilization. At present, no treatments are known for greatly stepping up the spontaneous rate.

Several workers tried to increase the frequency of monoploids in corn by using different agents and methods, such as heat, chemicals, x-radiation, mechanical injury, delayed pollination, and hybridization.

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[1] Central Experiment Station Contribution No. 1954. Thesis submitted to the Graduate School, U.P., 1956, for the M.Sc. degree.

[2] The author acknowledges the aid of Dr. T. L. York who suggested the problem and offered suggestions during the progress of the experiments, Drs. H. L. Everett and A. Rodolfo, and Mr. I. S. Santos for their criticisms of the manuscript, and to his many friends whose invaluable assistance made this manuscript possible.

The purpose of this work was to explore the possibility that certain chemicals may be able to change the rate of occurrence of monoploids.

The experiments were conducted in the Horticultural Crops Division, Department of Agronomy, U.P. College of Agriculture, from June, 1955 to December, 1956.

Meager information is available on the possibility of increasing the frequency of monoploids by the use of chemicals. Van Overbeck *et al.* (1941) used the growth regulators napthaleneacetic and indolebutyric acids on *Datura stramonium* in an attempt to stimulate parthenogenetic development of female gametes, but failed. York (1950)[3] treated the sides of approximately 30 stigmas of Red Jacket tomato (which has the recessive mutation potato leaf) with 0.3 per cent solution of colchicine (in lanolin) just before pollinating them with pollen from normal-leafed tomatoes. From these crosses, approximately 1400 seedlings were grown. Of these seedlings two potato-leaf plants appeared to be monoploids, judging from their size, vigor and nearly seedless fruits.

Effect of maleic hydrazide on growing pollen tubes. Maleic hydrazide has been observed to have anti-hormonal effect on various plants, inhibiting vegetative growth of grasses and hedges, the sprouting of onion bulbs, etc.

Greulach (1951) inhibited growth of tomato by spraying it with 2000 ppm of maleic hydrazide. After five weeks, the growth increment was only half that of the check. He stated that maleic hydrazide inhibited cell division rather than cell elongation. Only very high concentrations inhibited growth of the stem.

Linder (1951) reported that maleic hydrazide was translocated upward to the stem when applied to the leaves and that it was readily absorbed and translocated to the top of the plant when applied to the roots. Paterson and Wittwer (1953) found that 1000 to 25,000 ppm of maleic hydrazide sprayed on the foliage of four commercial varieties of onion 2, 11, and 29 days before harvest, significantly inhibited sprout growth during storage.

Zukel (1952) found that application of 4 pounds of maleic hydrazide inhibited growth of grasses on roadside areas when applied in May .

[3] Oral communication.

Maleic hydrazide is considered to be anti-hormonal because it inhibits vegetative growth. It also produces mitotic disturbances. Pollen, known to be especially rich in plant hormones, might be sensitive to the action of an anti-hormone chemical. If maleic hydrazide would be applied to the styles or similar tissue, its absorption and translocation might occur rapidly and could affect any pollen tube growing in the style.

The sperm nucleus divides into two daughter nuclei. Normally one joins with the egg to effect syngamy and the other with the polar nuclei to form endosperm nucleus. It is hypothesized that maleic hydrazide could affect pollen tube development and also syngamy, resulting in development of monoploid embryo with normal endosperm.

On the other hand, colchicine inhibits anaphase separation of mitotic and meiotic chromosomes. In species with a typical generative nucleus, it is presumed that the colchicine could effectively inhibit the division of the generative nucleus—a diploid one. If such a nucleus fused with the polar nuclei, the egg cell would be left to develop as a monoploid. It is not clear how colchicine could be effective in corn, inasmuch as the generative nucleus has divided before tube germination (Randolph, 1936); however, the chemical is proposed here on the strength of its apparent ability to induce monoploids in tomatoes.

MATERIALS AND METHODS

A stock of Golden Cross Bantam containing the basic color gene *A* but recessive for some genes which determine endosperm and seedling color characteristics was planted as the female in the vicinity of a pollen stock having the contrasting genes. The silks of the females were treated with one of the concentrations of either maleic hydrazide or colchicine, covered for 24 hours and then pollinated. The mature kernels were harvested and germinated and the frequency of monoploids determined according to genetic and anatomical criteria.

Concentrations used were 0.01, 0.05, 0.1, 0.2 and 0.4 per cent of colchicine and 50, 100, 250, 500 and 1000 ppm of maleic hydrazide.

Sweet corn was chosen as the experimental material because (1) genetic stocks are available to permit classification of both endosperm and embryo phenotypes; (2) the aggregation of many ovules and styles in one ear permits rapid treatment of large popula-

tions; and (3) any positive finding could be utilized readily in sweet corn breeding programs.

Golden Cross Bantam, a U.S.-produced single cross hybrid, was chosen because of its adaptability to Philippine conditions, its green stem color, and sugary character. It is characterized by a yellow kernel.

The brown line (*a B Pl R*) used a pollen parent on lines containing A^4. Such a cross gives purple aleurone, pinkish roots, and purple stem. In crosses with other corn carrying *A*, this stock produces hybrid offspring with purple aleurone and purple plant color. Golden Cross Bantam crossed with the brown stock would result normally in seedlings of purple aleurone and purple plant color.

The plants of Golden Cross Bantam were detasseled and the ears of the females were bagged as they formed. The silks were allowed to grow out of the ears before these were cut to allow a tuft of silks to form. During pollination, the ear shoot bag was removed momentarily. The shucks at the ear tip were separated slightly and the full complement of silks were arranged in a compact hank. Then the chemical was applied one to two inches from the tip of the young cob by means of a camel's hair brush moving distally. Enough solution was applied to insure moistening of all silks. Methocel in water applied to the silks served as control treatment.

The shucks were returned to their place. The ear was recovered with the ear shoot bag which was removed 24 hours later, at which time hand-pollination with pollen from the brown stock was done. The ear was covered again.

The treated ears were harvested before becoming fully dry to minimize the damage from kernel blast and rats. The ears were placed in wire trays and dried under the sun.

The kernels from each treated ear were classified under butt, middle, and tip. Kernels from small ears were classified under tip. Sugar kernels (*i.e.*, sweet corn selfs) and diseased kernels were discarded.

The kernels of each group were further classified by visual inspection into large and small. Several samples of the large and small kernels were weighed.

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[4] Thanks are due Dr. S. S. Chase of Dekalb Hybrid Seed Company, Dekalb, Illinois, U.S.A., for providing seeds of the brown stock.

The seeds treated with orthocide [5] were germinated in the Mangelsdorf germinator.

Three days after sowing, the roots of the seedlings were examined daily for pink coloration. For one or two days prior to classification into colored and noncolored roots, the trays were allowed to dry to obtain better color development.

Classification was completed 6 to 10 days after putting the seed in the germinator. Seedlings with non-colored roots (putative monoploids) were transplanted into 3-inch pots. The rest were discarded.

It was observed that width of leaf was quite variable, hence, not presented in this paper.

EXPERIMENTAL RESULTS

Kernel set. In general, there was no definite relationship between number of kernels set and the concentration of each of the two chemicals used. There were, however, more kernels in the maleic hydrazide treatments than in the colchicine treatments. Only the 1000 ppm maleic hydrazide treatment with 35 kernels per region differed significantly from the control with 40 kernels per region. On the other hand, all the colchicine treatments, except the 0.05 concentration with 36 kernels per region were very significantly lower in kernel set than the check. The tip with a mean of 39 kernels per region had significantly more kernels than the butt with 32 because the kernels from small ears were placed under tip. The mean squares for treatment and region were both highly significant.

Figure 1 shows graphically the relative number of kernels set at different concentrations and in different regions for maleic hydrazide and for colchicine. No consistent trend was observed, especially in the middle and tip regions. In the butt, the reduction in kernel set with increasing concentrations of both chemicals may have been due to the longer length of the stigma that the pollen had to travel through. If the male gamete was affected or weakened by the chemical treatment of the silk, the greater the distance it had to travel the less was its chance to reach the ovule and fertilize the egg nucleus.

Percentage of germination. Although there were highly significant differences among the treatments in percentage of germination, again no definite trend was indicated. The 50 ppm maleic

[5] 50 per cent captan.

hydrazide treatment (79 per cent) differed from the check (88 per cent) significantly at 0.01 level; this was probably due to the low percentage (66) of germination of the small kernels in the middle region. The percentages of germination in the colchicine treatments were about as high as those in the maleic hydrazide treatments, and neither were appreciably lower than the check.

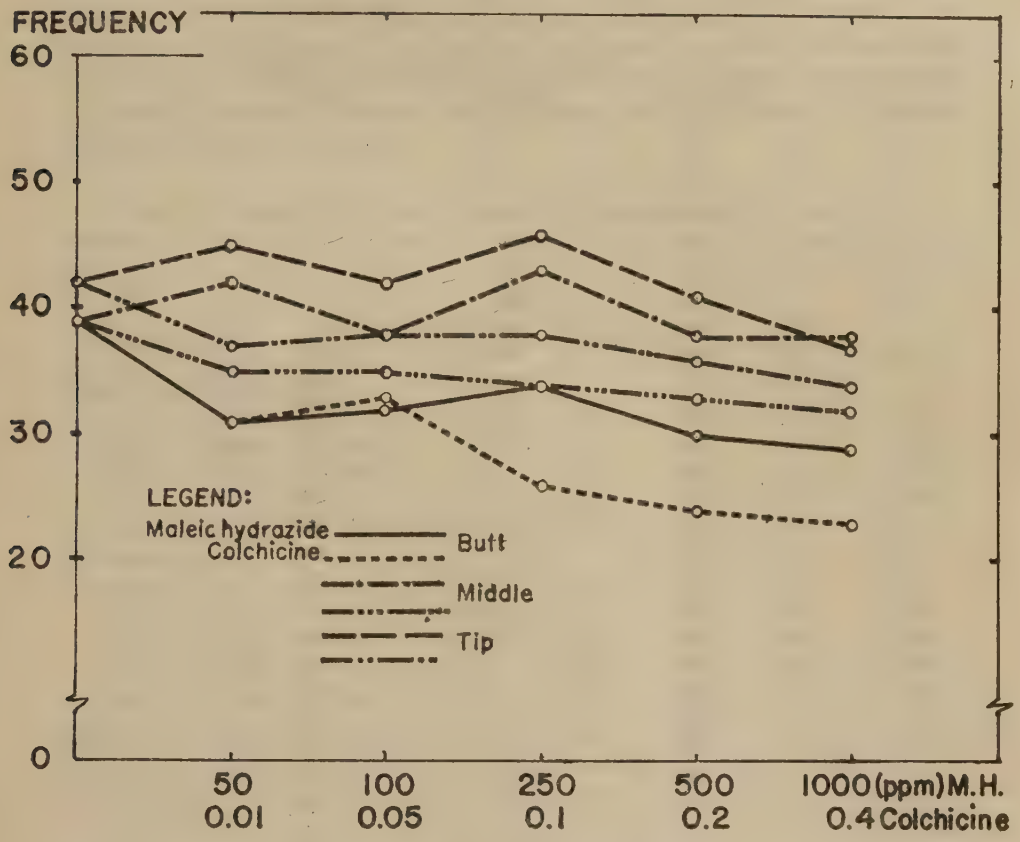

Fig. 1.—Effect of maleic hydrazide and colchicine on the number of kernels set in the different regions.

There was a highly significant difference between the two sizes. The mean percentage of germination was 89 for big kernels and 84 for small kernels. The S.M.D. at the 0.01 level was 4 per cent.

Frequency of monoploids. Identification of monoploid was based on root tip and plant color, relative plant vigor, and length of stomates. The number of monoploids and diploids falling under each

class of stomate length is shown in table 1. The mean lengths of the "monoploid" stomata varied from 12 to 25 microns; those of the "diploid" stomata, from 20 to 41 microns. The classification overlapped in the region of 20 to 25 microns. Final classification was made on the basis of relative weakness and lack of plant color.

TABLE 1.—*Number of monoploids and diploids falling under each stomate length class*

LENGTH OF STOMATES (MICRONS)	BASIC TYPES OF CHROMOSOME COMPLEMENTS	
	Monoploid	Diploid
12	2	
13	1	
14	3	
15	6	
16	7	
17	17	
18	16	
19	46	
20	56	20
21	24	40
22	10	36
23	9	36
24	1	22
25	1	23
26		26
27		25
28		44
29		56
30		62
31		32
32		13
33		10
34		1
35		5
36		0
37		1
38		3
39		4
40		1
41		3

The number of monoploids per thousand plants was small, ranging from 0 to 12.30 (table 2). Many zeros occurred (8 out of 66). The small numbers and the occurrence of many zeros necessitated the transformation of the actual frequency for analysis. If we let x

be the actual frequency and y the transformed value, then the appropriate transformation formula from the data is $y = \sqrt{0.5 + x}$.[6] The use of this formula resulted in the disappearance of the zeros and the shortening of the range from 0–12.30 to 0.71–3.58 (table 3). The analysis of variance table shows that all the mean squares were non-significant. This might be due to either over-correction resulting from transformation, or the relatively small sample sizes. At any rate, the computed F-value for treatment was not very far from the tabular F-value at the 0.05 level and thus suggests that single-degree-of-freedom analysis would bring out significant differences among certain treatments.

TABLE 2.—*Actual frequency (number per thousand, x) of monoploids*

TREATMENT	REGION						MEAN
	Butt		Middle		Tip		
	Big	Small	Big	Small	Big	Small	
0	1.47	0	6.02	0	4.24	4.25	2.66
Maleic Hydrazide (ppm)							
50	5.00	10.14	12.30	6.72	3.65	3.96	6.96
100	4.80	5.45	1.96	5.89	4.26	5.28	4.61
250	3.23	3.00	1.66	7.56	1.03	3.48	3.32
500	2.10	0	4.77	2.40	4.05	2.71	2.67
1000	2.19	1.10	2.79	2.59	1.81	0	1.74
Colchicine (%)							
0.01	0	3.29	3.45	1.89	1.19	5.31	2.52
0.05	0	1.35	2.94	0	1.59	1.92	1.30
0.1	3.91	3.53	3.78	1.08	1.44	3.82	2.92
0.2	3.43	0	4.53	1.84	1.39	6.38	2.92
0.4	1.30	4.21	1.83	0.98	6.84	2.12	2.88
Mean	2.49	2.91	4.18	2.81	2.86	3.56	3.13
Region Mean	2.70		3.40		3.21		3.13

SIZE	MEAN
Big	3.17
Small	3.09

Table 4 shows the single-degree-of-freedom analysis of treatment. A visual inspection of the data in table 2 showed that the 50 ppm maleic hydrazide treatment had a frequency of 6.96

[6] G. W. Snedecor, "Statistical Methods," The Collegiate Press, Inc., 1946, xiv + 845 p.

TABLE 3.—*Transformed values* $(y)^a$ *corresponding to the actual values* (x) *of monoploid frequency*

TREATMENT	REGION						MEAN
	Butt		Middle		Tip		
	Big	Small	Big	Small	Big	Small	
0	1.40	0.71	2.55	0.71	2.18	2.18	1.62
Maleic Hydrazide (ppm)							
50	2.35	3.26	3.58	2.69	2.04	2.11	2.67
100	2.30	2.44	1.57	2.53	2.18	2.40	2.23
250	1.80	1.87	1.47	2.84	1.24	1.99	1.86
500	1.61	0.71	2.30	1.70	2.13	1.79	1.70
1000	1.64	1.26	1.81	1.76	1.52	0.71	1.45
Colchicine (%)							
0.01	0.71	1.95	1.99	1.55	1.30	2.41	1.65
0.05	0.71	1.36	1.85	0.71	1.45	1.56	1.27
0.1	2.10	1.98	2.07	1.26	1.39	2.08	1.81
0.2	1.98	0.71	2.22	1.53	1.37	2.62	1.73
0.4	1.34	2.17	1.53	1.22	2.71	1.62	1.76
Mean	1.63	1.67	2.08	1.68	1.77	1.95	1.79
Region mean	1.65		1.88		1.86		1.79

$^a y = \sqrt{0.5 + x}$

SIZE	MEAN
Big	1.82
Small	1.76

Analysis of variance

SOURCE OF VARIANCE	D.F.	S.S.	M.S.	COMPUTED F-VALUE	TABULAR F-VALUE	
					0.05	0.01
Treatment	10	8.54	0.85	1.93	2.35	3.37
Region (R)	2	0.72	0.36			
Size (S)	1	0.06	0.06			
(T × R)	20	2.93	0.15			
(T × S)	10	3.69	0.37			
(R × S)	2	1.02	0.51	1.61	3.49	5.85
Error	20	8.76	0.44			
Total	65	25.72				

monoploids per thousand, while the check (no treatment) had 2.66 per thousand. The rest of the maleic hydrazide treatments did not differ significantly from the check. The single-degree-of-freedom analysis also revealed that the treatments with lower concentrations of maleic hydrazide (50 ppm and 100 ppm) had more monoploids than those with higher concentrations (500 ppm and 1000 ppm). The check and five colchicine treatments did not differ from one another. The average of all maleic hydrazide treatments did not significantly differ from the check and the colchicine treatments. The average of all the chemical treatments did not differ from the check.

TABLE 4.—*Single-degree-of-freedom analysis of treatments*

COMPARISONS	M.S.	COMPUTED F-VALUE	TABULAR F-VALUE 0.05	0.01
MH vs. Colch.	1.72	3.91		
Check vs. Treated	0.21			
Check vs. Colch.	0.04			
Check vs. MH	0.64	1.51		
Check vs. MH-1000	0.09			
Check vs. MH-500	0.02			
Check vs. MH-250	0.18			
Check vs. MH-100	1.14	2.58		
Check vs. MH-50	3.31	7.52 [a]	4.35	8.10
MH-50 & 100 vs. 500 & 1000	4.60	10.45 [b]	4.35	8.10
Colch.-.01 & .05 vs. 0.2 & 0.4	0.50	1.15		
Check vs. Colch.-.01	0.03			
Check vs. Colch.-4.	0.37			
Error	0.44			

[a] Significant at 0.05 level.
[b] Significant at 0.01 level.

Figure 2 shows graphically the frequency of monoploids obtained at different concentrations of maleic hydrazide and colchicine.

DISCUSSION

Methocel treatment of the silk of Golden Cross Bantam without maleic hydrazide or colchicine resulted in the production of 2.66 monoploids per thousand (table 2). This compares favorably with monoploid frequencies obtained without active chemical treatments by previous workers. Chase (1947; 1949) obtained a frequency of 0.63 monoploid per thousand from single-cross materials, 1.20 mono-

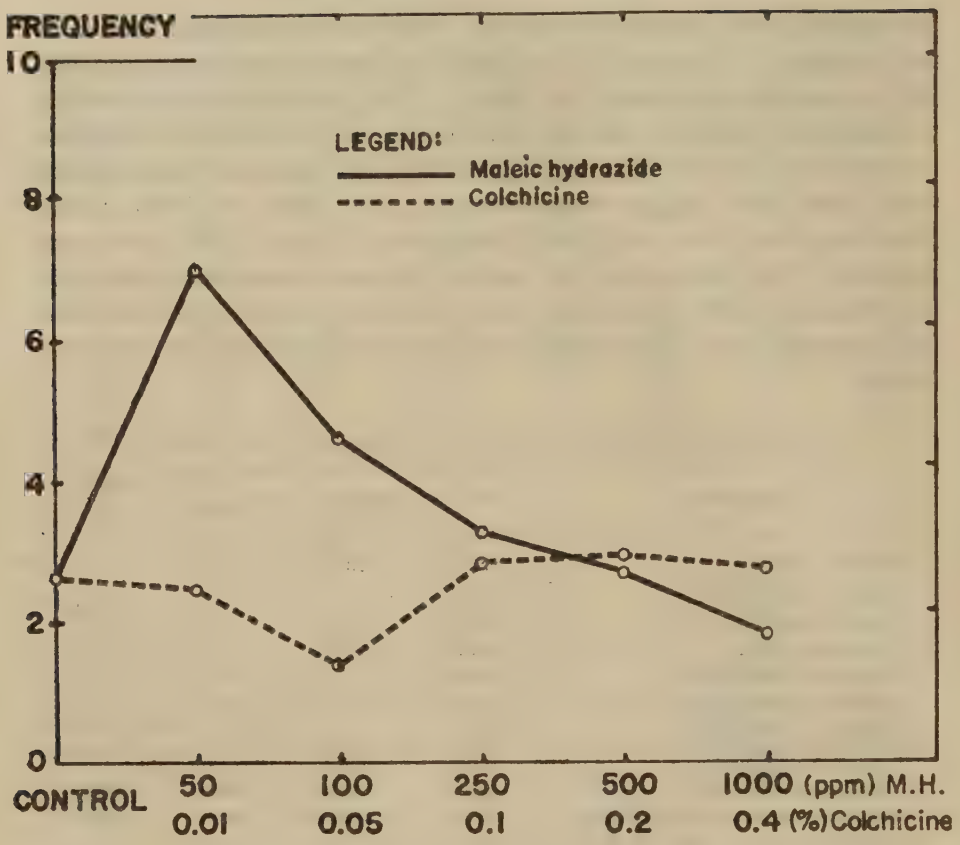

Fig. 2.—Frequency (number per thousand) of monoploids

ploids per thousand from inbred materials, and 0.39 and 0.75 monoploid per thousand from two open-pollinated varieties. Johnson (1953)[7] obtained a frequency of 0.53 monoploid per thousand from a single cross, and 0.69 monoploid per thousand from a mixture of different stocks. Golden Cross Bantam has been known to produce a large number of naturally-occurring monoploids.

The experiments yielded information on the effect of treatments on seed set and seed viability. There were significant differences in seed viability among treatments, but no definite trend was observed. It can be assumed that high concentrations of colchicine and maleic hydrazide are not deleterious to seed viability.

[7] W. C. Johnson, "Haploids in Southern varieties, single-cross hybrids, and inbred lines of corn." (North Carolina State College M.S. Thesis, 1953. Unpublished).

It appeared from the range of colchicine concentrations used that colchicine would not be of value in increasing the frequency of monoploids. Instead, there is a reduction in frequency especially with the 0.05 per cent treatment. The interest in this research was to *increase* the frequency, but the fact that the frequency can be decreased is also of interest for it indicates that frequency can be influenced by external application of chemicals. If the use of colchicine for increasing frequency of monoploids were to be evaluated further, the range of concentrations should include concentrations lower than 0.01 per cent and higher than 0.4 per cent.

In the introduction, the hypothesis that maleic hydrazide acting as an anti-hormone might step up the monoploid frequency by inactivating in certain pollen tubes the nucleus destined to fuse with the egg was advanced. Data obtained show that the 50 ppm maleic hydrazide treatment did increase monoploid frequency, but that treatments with greater concentrations did not. The question arises: do these data substantiate the hypothesis? While a definite answer cannot be given, it would appear that the effect of maleic hydrazide on frequency of monoploidy is not due to inhibition as originally hypothesized. If it were due to *inhibition* higher concentrations of maleic hydrazide would give higher frequencies of monoploids.

The greater effectiveness of lower concentrations indicated that maleic hydrazide could have the effect of certain plant hormones. Paterson (1952) and Kasa and Thompson (1951) as cited in the abstract made by U.S. Rubber Company (1952), showed that at lower concentrations maleic hydrazide stimulates sprouting in onions and potatoes and bolting in young lettuce. Further studies on the use of maleic hydrazide for increasing monoploid frequency should include concentrations lower than 50 ppm and those between 50 ppm and 100 ppm.

SUMMARY AND CONCLUSION

An exploratory study on the possible use of maleic hydrazide and colchicine for increasing monoploid frequency in sweet corn was conducted.

Concentrations of maleic hydrazide were 50, 100, 250, 500, and 1000 ppm; those of colchicine, 0.01, 0.05, 0.1, 0.2, 0.3, and 0.4 per cent. Methocel was added to the aqueous solutions and served satisfactorily as the carrier. The silks were treated 24 hours prior to pollination. Methocel in water was applied on the silk of the check.

In general there was no definite relationship between concentrations of each of the chemicals, the number of kernels set and percentage of germination. However, there was a tendency of kernels in the butt region to decrease as the concentration of either of the two chemicals was increased. A probable explanation was advanced—some pollen tubes affected by chemical treatment of the silk failed to reach the eggs in the butt region, and so, failed to effect fertilization. A relatively high frequency of monoploids was obtained in the check treatment because the frequency of naturally-occurring monoploids in Golden Cross Bantam is known to be higher than that in many other varieties.

Over-all statistical analysis of frequency of monoploids in the different chemical treatments showed no significant differences among them. However, a single-degree-of-freedom analysis showed that the 50 ppm maleic hydrazide treatment significantly increased monoploid frequency. Higher concentrations (500 ppm and 1000 ppm) of maleic hydrazide produced significantly fewer monoploids per thousand than the lower concentrations (50 ppm and 100 ppm). Concentrations lower than 50 ppm and 100 ppm were suggested for future studies with maleic hydrazide.

None of the colchicine treatments significantly increased the monoploid frequency. Concentrations lower than 0.01 per cent and higher than 0.4 per cent were suggested for future studies.

There were 200 monoploid plants in 61,134 seeds; average frequency was 3.27 monoploids per 1,000 seeds.

LITERATURE CITED

Abstract of Maleic hydrazide Literature Summary. 1952. U. S. Rubber Co., Naugatuck, Conn. Naugatuck Chemical Div. 161 East 42nd St. N.Y. 17, N.Y.

CHASE, S. S. 1947. Techniques for isolating monoploid maize plants. Amer. Jour. Bot. **24**: 582.

————. 1949. Monoploid frequencies in commercial double-cross hybrids and inbred lines. Genetics **34**: 328-332.

GREULACH, V. A. 1951. The effects of various concentrations of maleic hydrazide on tomato and etiolated bean plants. Plant Physiology **26**: 848-851.

LINDER, P. L. 1951. Absorption of some new herbicides by plants. Proc. Northeastern Weed Control Conference.

PATERSON, D. R. and S. H. WITTWER. 1953. Further investigations on the use of maleic hydrazide as a sprout inhibitor for onions. Amer. Soc. Hort. Sci. Proc. **62**: 402-410.

RANDOLPH, L. F. 1936. Developmental morphology of caryopsis in maize. Jour. Agric. Res. **53**: (12).

VAN OVERBECK *et al.* 1941. Chemical stimulation of ovule development and its possible relation to parthenogenesis. Amer. Jour. Bot. **28**: 647-656.

ZUKEL, J. W. 1952. Progress report on use of maleic hydrazide for grass inhibition on highway areas. Paper presented to Highway Research Board, National Academy of Sci. Wash., D.C.

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One purpose of science is to find ways in each field of operation to cut the costs. That may mean improved varieties (like hybrid corn); or better methods of feeding stock; or lime and fertilizer for the land; or conserving water and preventing erosion; or breeding for production, for earlier maturity, and for longer life; or sure control of insects and plant diseases; or efficient marketing of stock and produce.

—*C. R. Orton*

AN EVALUATION OF CUBAN CORN AS A SOURCE OF GENETIC DIVERSITY FOR PHILIPPINE HYBRIDS [1]

IBARRA S. SANTOS [2]

A strain of Cuban Yellow Flint was evaluated as a source of genetically diverse inbred lines to be used in double cross combinations with inbred lines from College Yellow Flint, a local high-yielding open-pollinated variety. Single crosses between inbred lines from the Cuban Yellow Flint and those from the College Yelow Flint were included in performance tests together with single crosses among the Cuban Yellow lines and single crosses among the College Yellow lines.

Results showed that the best double cross hybrids of Cuban Yellow and College Yellow inbred lines are better than the best obtainable employing only College Yellow lines or only Cuban Yellow lines.

This study deals with the yield trials of single crosses among the College Yellow inbred lines,[3] among the Cuban Yellow inbred lines, and single crosses between College Yellow inbred lines and Cuban Yellow inbred lines, and was conducted at College, Los Baños, Laguna, Philippines during the wet season of 1953.

Early in the breeding program it became necessary to evaluate the inbred-source varieties being used to enable the breeder to decide whether to seek better sources or to continue with the present materials on hand if they showed at least a little promise. A study of whatever meagre data that were available could aid the corn breeder in making such a decision. The present paper is a report of an attempt to evaluate and discuss these points as related to the Philippine corn improvement program.[4]

East (1936) wrote that "In 1912 East and Hayes expressed the opinion, based on much too meagre evidence, that the amount of he-

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[1] Miscellaneous Contribution No. 36. Based on the thesis presented by the author for graduation with the degree of Master of Science from the University of Nebraska, U.S.A., August, 1955.

[2] Instructor in Agronomy (Plant Breeding), U.P. College of Agriculture. The author is grateful to Drs. H. K. Hayes, J. H. Lonnquist and C. O. Gardner for advice and criticisms.

[3] A high yielding native variety introduced from Cuba in 1935 by Dr. J. M. Capinpin, Head, Department of Agricultural Botany, U.P. College of Agriculture.

[4] Started in 1949 by Dr. D. L. Umali, Head, Division of Plant Breeding, Department of Agronomy, U. P. College of Agriculture.

terosis expressed in an F_1 plant is roughly proportional to the genic differentiation in the two parental stocks, provided normal ontogeny is possible." He confirmed this statement based on additional evidence by writing: "Heterosis does increase as the genetic disparity of the parental stocks increases, on the average!"

Wu (1939) presented experimental results to show the relationship between hybrid vigor in crosses and the origin of corn inbred lines. The inbreds he used were obtained by the pedigree method of selection from single crosses. With these inbreds three types of single crosses were made: (a) crosses among inbreds derived from the same source or single cross, thus having the two parent inbreds in common, (b) crosses among inbreds derived from two original single crosses with one parent inbred in common, and (c) crosses among inbreds derived from two original single crosses with no parent inbred in common. On the average, he found that Group A crosses yielded significantly less than either Group B or Group C crosses. Group C crosses did not differ significantly in yield from Group B crosses. Mention was made of a very exceptional case wherein a Group A cross gave a good yield. Hayes and Johnson (1939), in a similar study, reported results that were not very different from those obtained by Wu. Out of 43 single crosses with no parent inbred in common, 28 (65 per cent) were accepted as equal in yielding ability to double crosses adapted in the regions of trials. Out of nine single crosses between two inbreds from two single crosses with one parent inbred in common, six (67 per cent) were equal in yield to the double crosses. Only one (7 per cent) out of 14 single crosses between inbreds derived from the same single cross gave a yield which was about equal to those of the double crosses. The fact that the top-cross combining abilities of the inbreds in each group of crosses were about the same left the difference among the groups of crosses to be due only to the difference in extent of similarity of the parents. The following year, Johnson and Hayes (1940) presented additional information on the relation between genetic diversity of inbred lines and their yield in hybrids.

Eckhardt and Bryan (1940) have shown the importance of genetic diversity in the parental single crosses of a double cross. Designating inbreds from one variety as A and B, and from another variety as Y and Z, they found that except for one or two exceptions, the double-cross combination (A $\times$ B) (Y $\times$ Z) was consistently higher yielding than either (A $\times$ Y) (B $\times$ Z) or (A $\times$ Z) (B $\times$ Y).

MATERIALS AND METHODS

College Yellow Flint and Cuban Yellow Flint differ in agronomic characters. College Yellow Flint has narrow light-green leaves, smooth leafsheath, long and thin ears, and yellow kernels. Cuban Yellow Flint is generally a little taller, with broad, dark-green leaves, hairy leafsheaths, stout stalks, shorter and more profusely husked ears, and reddish orange-yellow kernels. It is considered to mature a little later than College Yellow Flint.

Twenty-three inbred lines from both varieties visually selected from about 100 College Yellow inbred lines were top-crossed to the Cuban Yellow variety. The yield trial used an incomplete-block design with 25 entries and six replications during the dry season of 1951-1952 (November to March). Likewise, twenty-three visually selected Cuban Yellow inbred lines were top-crossed to the College Yellow variety. These top crosses together with the source varieties were tested in a yield trial using an incomplete-block design with 25 entries and six replications during the wet season of 1952 (May to September).

The ten highest combining College Yellow inbreds and six highest combining Cuban Yellow inbreds were selected on the basis of their top-cross performance. Six 15-hill rows of each inbred were grown in the breeding nursery during the dry season of 1952-1953. An attempt was made to make by hand pollination all the possible crosses among the College Yellow inbreds, and the Cuban Yellow inbreds, and between the College Yellow inbreds and Cuban Yellow inbreds. Of the 120 possible single-cross combinations, seed of 108 was obtained.

During the wet season of 1953, a yield trial of these crosses was conducted at the Experiment Station of the U. P. College of Agriculture. The crosses were divided into five subgroups of about 24 entries each. Each subgroup included the two parental varieties as checks. These five experimental subgroups were labeled Subgroups XI to XV, respectively, as part of the corn yield trials grown by the Division of Plant Breeding during that season. Subgroups XI and XII were composed mainly of crosses among the College Yellow inbreds; Subgroup XIII, of crosses among the Cuban Yellow inbreds; and Subgroups XIV and XV, of crosses between the College Yellow inbreds and Cuban Yellow inbreds. Each experimental subgroup was a randomized-complete-block experiment.

Planting was done on May 30, 1953. Single-row plots of 17 hills each were one meter apart; hills in the rows were one-half meter apart. Four kernels were planted to a hill. The hills were thinned to two plants per hill two weeks after planting. Ammonium phosphate (12-12-0) was applied as a side dressing at the rate of 200 kilograms per hectare before thinning. Ammonium sulfate (20.5 per cent N) was applied between the rows at the rate of 100 kilograms per hectare five weeks after planting.

The crosses were harvested on September 7, 1953. The harvest from each plot was kept separate. The ears were weighed unhusked at the time of harvest and then allowed to dry for about three days in preparation for shelling. Data on ear length and number of grain rows for each plot were recorded prior to shelling. The weight of the ear corn from each plot was obtained before shelling and of the shelled grains immediately after shelling. The moisture percentage of the shelled grain from each plot was determined from a 100-gram sample of the shelled grain placed in an oven at 100°C and dried to constant weight. The weight of shelled grain from each plot in kilograms at the determined moisture content was converted to cavans of shelled corn per hectare at 16 per cent moisture by using the following formula:

$$Y = y \times \frac{(100 - m)}{100} \times \frac{1}{0.84} \times \frac{10{,}000}{0.5 \times h} \times \frac{1}{58.5}$$

where,

Y = yield in cavans of shelled corn per hectare at 16 per cent moisture,
y = weight of shelled corn for the plot in kilograms,
m = moisture content of the shelled corn in per cent,
h = number of hills harvested,
10,000 = number of square meters per hectare,
0.5 = number of square meters occupied by one hill,
58.5 = number of kilograms of shelled corn per cavan, and
1/0.84 = factor for converting into weight at 16 per cent moisture.

The process was simplified by summarizing the constants into factors each corresponding to a certain number of hills. The computation for yield in cavans per hectare, therefore, amounted to getting the product of the weight of shelled corn in kilograms by its percentage of "dry matter" by the appropriate factor for the number of hills harvested from that particular plot.

The average yield of each entry in cavans per hectare was further converted into percentage yields using the average of the yields of the checks in the experimental subgroup to which it belonged, as 100 per cent. This was done to make comparisons between entries from the different subgroups possible.

EXPERIMENTAL RESULTS

The analysis of variance for the five experimental subgroups is given in table 1. The separate error variances estimated for

TABLE 1.—*Analysis of variance of yields (cavans per hectare) for all possible single-cross combinations among ten inbred lines from College Yellow Flint and six from Cuban Yellow Flint* [a]

SOURCE OF VARIATION	D.F.	MEAN SQUARES
Subgroups of varieties	4	111,765.71
Replications within subgroups	10	346.08 [b]
Varieties within subgroups	101	185.83 [b]
Subgroup XI	22	292.09 [b]
Subgroup XII	18	172.51 [b]
Subgroup XIII	17	136.95 [b]
Subgroup XIV	22	158.73 [b]
Subgroup XV	22	155.33 [b]
Replication × Varieties within subgroups	202	55.08
Subgroup XI	44	56.23
Subgroup XII	36	59.67
Subgroup XIII	34	87.12
Subgroup XIV	44	35.68
Subgroup XV	44	44.87
Total	317	

[a] Arranged in five experimental subgroups; the two source varieties were included in each subgroup.
[b] Significant at the one per cent level.

each randomized-complete-block experiment varied. Hence, they were checked for homogeneity with Bartlett's Chi-square test as illustrated by Snedecor (1946) and were found to be relatively homogeneous ($0.05 < P < 0.10$). Thus, a pooled error variance (55.08) was computed. The variety mean squares were tested with this pooled error variance, and all were found significant at the one per cent level.

The percentage yields of the crosses among the College Yellow inbreds are given in table 2; those between the College Yellow inbreds and Cuban Yellow inbreds, in table 3; and those among the Cuban Yellow inbreds, in table 4. Inbred lines A100 to A109 are

TABLE 2.—*Relative yields of single crosses among the ten lines out of College Yellow Flint (Mean of check varieties = 100 per cent)*

LINE	A100	A101	A102	A103	A104	A105	A106	A107	A108	A109
A100	—									
A101	67.7	—								
A102	127.8	113.0	—							
A103	112.2	101.0	122.8	—						
A104	117.6	114.1	124.7	111.1	—					
A105	122.3	104.3	123.3	102.6	97.6	—				
A106	126.8	127.0	119.8	102.6	117.0	126.3	—			
A107	133.9	117.2	97.6	143.4	118.4	129.6	141.8	—		
A108	—[a]	—[a]	124.2	—[a]	—[a]	—[a]	—[a]	144.5	—	
A109	119.3	129.9	87.1	96.0	121.4	125.4	127.2	128.3	128.1	—
Mean	116.0	109.3	114.5	111.5	115.2	116.4	123.6	126.3	—	118.1

[a] Single-cross seed not obtained.

TABLE 3.—*Relative yields of crosses between ten College Yellow lines and six Cuban Yellow lines (Mean of check varieties = 100 per cent)*

COLLEGE YELLOW LINE	CUBAN YELLOW LINES						
	A110	A111	A112	A113	A114	A115	Mean
A100	117.0	103.3	113.7	95.1	90.9	—[a]	104.0
A101	101.8	103.2	101.2	86.9	89.2	—[a]	96.5
A102	137.0	125.3	146.9	128.4	116.3	—[a]	130.8
A103	126.8	121.2	122.4	142.2	99.2	130.0	122.4
A104	121.6	119.5	118.7	136.8	130.4	136.6	125.4
A105	117.1	108.8	123.0	138.5	109.2	—[a]	119.3
A106	121.5	135.2	126.5	126.3	109.6	124.7	125.8
A107	124.3	116.2	109.0	123.0	106.6	—[a]	115.8
A108	106.8	91.2	135.0	105.3	95.2	96.9	106.7
A109	93.2	100.4	113.6	100.6	90.4	—[a]	99.8
Mean	116.7	112.4	121.0	118.3	103.7	—	

[a] Single-cross seed not obtained.

TABLE 4.—*Relative yields of the crosses among six lines out of Cuban Yellow Flint (Mean of check varieties = 100 per cent)*

LINE	A110	A111	A112	A113	A114	A115
A110	—					
A111	69.6	—				
A112	81.5	41.4	—			
A113	83.1	75.2	65.2	—		
A114	77.0	76.1	74.6	80.0	—	
A115	74.0	84.4	78.9	80.0	71.5	—
Means	77.0	69.3	68.3	76.7	75.8	77.8

from College Yellow Flint; A110 to A115, from Cuban Yellow Flint. Where a cross had only two replications, instead of three, an adjusted yield was computed based on the relative yield levels of all the three replications taking into account only the crosses that were complete in all three replications.

In tables 2 and 4, the mean yield for each line in crosses with other lines from the same variety is given. Only three out of the nine College Yellow inbred intracrosses involving A108 were obtained; hence, no average was calculated for it, and its three crosses were not used in getting the means of remaining inbreds. The means for the College Yellow inbreds are based on nine crosses; those for the Cuban Yellow inbreds, on five crosses. In table 3, the means for the College Yellow lines in crosses with the Cuban Yellow lines and vice-versa are given. Each average of College Yellow is based on five crosses; each average of the Cuban Yellow, on ten crosses. No average was calculated for A115 since it had only four crosses with the College Yellow inbred lines.

Table 5 shows the frequency distribution of the percentage yields of the different types of single crosses and those of the check varieties in the five complete-block experiments. The respective distributions of the College Yellow inbred intracrosses and of the College Yellow $\times$ Cuban Yellow inbred intracrosses did not differ greatly; their mean percentage yields did not differ significantly. The mean percentage yields of the College Yellow inbred intracrosses (117.8 per cent) and of the College Yellow variety (115.0 per cent) were very similar. The mean percentage yield of the Cuban Yellow inbred intracrosses was surprisingly low (74.2 per cent). However, as shown in table 6, the yield levels of the check varieties in the five experimental subgroups give a possible explanation. The yields of the check varieties in the different experimental subgroups are given in cavans per hectare. The average of each check for the five experimental subgroups and the average of the checks in each experimental subgroup are also given. The considerably higher yield of the Cuban Yellow variety in Subgroup XIII increased the average of the checks of that subgroup materially. If the seeming irregularity is to be taken into account, the percentage yield of each of the Cuban Yellow inbred intracrosses must be increased by about ten per cent, and hence, the mean percentage yield (74.2 per cent) would be increased by ten per cent to 84.2 per cent, which is in close agreement with the mean percentage yield of the Cuban Yellow variety (84.2

TABLE 5.—*Frequency distributions of percentage yields of the different types of single crosses together with the check varieties (Based on tables 2, 3 and 4)*

CROSS	CLASS CENTER								NUMBER OF ENTRIES	MEAN
	40	55	70	85	100	115	130	145		
College Yellow inbred intracrosses			1	1	7	12	15	3	39	117.8 ± 2.5
College Yellow × Cuban Yellow inbred intercrosses				5	14	16	16	3	54	115.0 ± 2.1
Cuban Yellow inbred intracrosses	1		8	6					15	74.2 ± 2.7
College Yellow				5					5	115.6 ± 2.2
Cuban Yellow						5			5	84.2 ± 2.2

per cent). Even with this adjusted mean percentage yield the Cuban Yellow inbred intracrosses would still be significantly lower yielding than those of the other two types of crosses.

TABLE 6.—*Actual yields in cavans per hectare*[a] *of the check varieties in the different experimental subgroups*

VARIETY	SUBGROUP					VARIETY MEANS
	XI	XII	XIII	XIV	XV	
College Yellow	70.2	64.9	71.4	59.2	61.0	65.3
Cuban Yellow	44.7	44.6	58.3	43.6	47.5	47.7
Subgroup Means	57.5	54.8	64.9	51.4	54.3	56.5

[a] One cavan per hectare = 0.9320 bushel per acre.

The means for the agronomic characters, days from planting to silking, plant height, percentage of root and stalk lodging, ear length, and number of kernel rows are shown in table 7.

The means of the three types with regards to the days from planting to silking were all significantly different from each other, with the College Yellow inbred intracrosses being the earliest maturing (52.5 days) and the Cuban Yellow inbred intracrosses, the latest maturing (55.0 days). The College Yellow variety was significantly earlier maturing (52.6 days) than the Cuban Yellow variety (56.0 days). The College Yellow inbred intracrosses did not differ significantly in maturity from the College Yellow variety nor did the Cuban Yellow inbred intracrosses differ from the Cuban Yellow variety.

With regards to the other agronomic characters, the pattern was not as clear-cut as with days from planting to silking. In plant height, the College Yellow inbred intracrosses (285.6 cm.) were significantly shorter on the average than the College Yellow variety (298.4 cm.), Cuban Yellow inbred intracrosses (298.1 cm.), and College Yellow × Cuban Yellow inbred intercrosses (300.0 cm.) which did not differ significantly. The Cuban variety (308.8 cm.) was not significantly taller than the College Yellow variety (298.4 cm.) although as mentioned previously the Cuban Yellow variety was generally considered to be taller on the basis of visual observation.

The three types of crosses did not differ significantly in percentage of root lodging although the values indicated a higher percentage of root lodging for College Yellow intracrosses (14.80 per cent) than either the College Yellow × Cuban Yellow intercrosses

TABLE 7.—*Summary of performance for the different types of crosses and of the check varieties grown at the UP College of Agriculture, 1953*

TYPE OF CROSS	NUMBER OF ENTRIES	RELATIVE YIELD	DAYS TO SILKING	PLANT HEIGHT	LODGING		EAR LENGTH	KERNEL ROW
					Root	Stalk		
		per cent	*No.*	*cm.*	*per cent*	*per cent*	*cm.*	*No.*
College Yellow intracrosses	39	117.8 ± 2.5	52.5 ± 0.6	285.6 ± 2.1	14.80 ± 2.04	39.59 ± 2.11	15.67 ± 0.27	14.37 ± 0.09
College Yellow × Cuban Yellow intercrosses	54	115.0 ± 2.1	53.7 ± 0.1	300.0 ± 2.0	11.65 ± 1.22	62.51 ± 2.21	15.51 ± 0.08	14.33 ± 0.08
Cuban Yellow intracrosses	15	74.2 ± 2.7	55.0 ± 0.2	298.1 ± 3.2	10.02 ± 2.64	56.56 ± 4.33	14.85 ± 0.13	14.64 ± 0.15
College Yellow	5	115.6 ± 2.2	52.6 ± 0.2	298.4 ± 3.6	19.18 ± 3.93	49.04 ± 6.56	16.00 ± 0.20	14.10 ± 0.14
Cuban Yellow	5	84.2 ± 2.2	56.0 ± 0.7	308.8 ± 6.6	18.34 ± 2.63	50.44 ± 6.28	14.90 ± 0.23	14.00 ± 0.24

(11.65 per cent) or the Cuban Yellow intracrosses (10.02 per cent). While the College Yellow intracrosses did not differ significantly in percentage of root lodging, on the average, from the College Yellow variety (19.2 per cent), the Cuban Yellow intracrosses differed significantly from the Cuban Yellow variety (18.3 per cent), the L.S.D. being about 7.8 per cent. The College Yellow and Cuban Yellow varieties did not differ significantly with respect to either root or stalk lodging. The College Yellow × Cuban Yellow intercrosses (62.5 per cent) and the Cuban Yellow intracrosses (56.6 per cent) were again about the same in percentage of stalk lodging while the College Yellow intracrosses (39.6 per cent) were significantly lower in percentage of stalk lodging. As shown in table 8 the College Yellow intracrosses, though not significantly higher in percentage of root lodging, were slightly more susceptible to root lodging than the other two types of crosses.

Data on single crosses between College Yellow inbreds and Cuban Yellow inbreds may be used to predict performance of double crosses between College Yellow single crosses and Cuban Yellow single crosses, using Jenkins' method B (Jenkins, 1934). However, absolute reliance should not be placed on the predicted yield of any one double cross since the tests involved only one season and one location. However, if the corn breeder were to proceed as originally planned, on the basis of these data, he would do well if he used as single-cross parents in isolated double-crossing plots, the single crosses of College Yellow and of Cuban Yellow giving the better predicted combinations. These could then be tested in performance trials. Table 8 shows the average relative combining abilities of College Yellow single crosses with Cuban Yellow single crosses. Each figure is an average of ten predicted doubles using Jenkin's Method B. Table 9 shows the average relative combining ability of Cuban Yellow single crosses with College Yellow single crosses. Each figure is an average of 45 predicted double crosses, except in those four single crosses involving A115 which are averages each based on only six predicted double crosses. A102 × A103, A102 × A104, A102 × A105, A102 × A106, A102 × A107, A103 × A104, and A104 × A106 are the higher combining College Yellow single crosses. On the other hand, A110 × A112, A110 × A113, A111 × A112, and A112 × A113 are the Cuban Yellow single crosses that might be used as parents. In the commercial production of this type of double cross, it would be advantageous to use the College Yellow single cross as the seed

TABLE 8.—*Mean relative combining ability* [a] *of College Yellow single crosses as determined by crosses with Cuban Yellow single crosses*

SINGLE CROSS	AVE. COMB. ABILITY	SINGLE CROSS	AVE. COMB. ABILITY	SINGLE CROSS	AVE. COMB. ABILITY
A100 × A101	100.3	A101 × A108	101.6	A104 × A105	122.4
× A102	117.4	× A109	99.1	× A106	124.6
× A103	113.2	A102 × A103	126.6	× A107	120.6
× A104	114.7	× A104	128.1	× A108	115.9
× A105	111.7	× A105	125.1	× A109	112.5
× A106	113.9	× A106	127.3	A105 × A106	121.6
× A107	109.9	× A107	123.3	× A107	117.3
× A108	105.4	× A108	119.6	× A108	113.0
× A109	101.9	× A109	115.2	× A109	109.5
A101 × A102	113.6	A103 × A104	123.9	A106 × A107	119.8
× A103	109.4	× A105	120.9	× A108	115.3
× A104	110.9	× A106	122.8	× A109	111.7
× A105	107.9	× A107	119.1	A107 × A108	111.3
× A106	110.1	× A108	114.6	× A109	107.7
× A107	106.1	× A109	111.0	A108 × A109	103.2

[a] Each based on 10 predicted doubles.

TABLE 9.—*Mean relative combining ability* [a] *of Cuban Yellow single crosses as determined by crosses with College Yellow single crosses*

SINGLE CROSS	AVE. COMB. ABILITY	SINGLE CROSS	AVE. COMB. ABILITY	SINGLE CROSS	AVE. COMB. ABILITY
A110 × A111	114.6	A111 × A112	116.7	A112 × A114	112.4
× A112	118.8	× A113	115.4	× A115 [b]	123.9
× A113	117.5	× A114	108.0	A113 × A114	111.1
× A114	110.2	× A115 [b]	119.4	× A115 [b]	124.9
× A115	120.6	A112 × A113	119.7	A114 × A115 [b]	114.7

[a] Each based on 45 predicted doubles.
[b] Each based on only six predicted doubles.

parent, and the Cuban Yellow single cross as the pollen parent since College Yellow crosses appear to be better seed producers.

DISCUSSION AND CONCLUSION

The yields of the College Yellow × Cuban Yellow single crosses were not as remarkable as was expected from the high degree of apparent genetic diversity between the two source varieties. Previous data on the Cuban Yellow variety showed that it is a higher yielder than Native Yellow Flint (College Yellow) in the dry season and was recommended for use in dry-season plantings. Evidently,

the Cuban corn does not do as well in the wet season as it does in the dry season. F_1 varietal crosses of this Cuban Yellow variety with some eight Philippine regional strains, exhibited heterosis in yield of ear corn and shelled grains ranging from 18 to 36 per cent over the higher yielding parent. This indicates that this strain of Cuban Yellow Flint is genetically different from the native strains of corn.

In spite of the unadaptability under wet-season conditions brought in by the Cuban germplasm, there was some evidence that hybrids of College Yellow and Cuban Yellow could do very much better in seasons more favorable to the Cuban germplasm. The unusually wet season during which the test was conducted was unfavorable to the Cuban variety. This fact was reflected in the very low yield of the Cuban Yellow variety as compared to that of the College Yellow variety. The average percentage yields of the Cuban Yellow intracrosses are perhaps poorer than might be expected due to the unusually high yield of one (Cuban Yellow variety) of the checks in the experimental subgroup in which these crosses were included.

The highest yielding double-crosses based on predicted yield that could be obtained from among the College Yellow × Cuban Yellow double crosses were generally higher than those that could be obtained from intercrosses among the College Yellow lines only.

It is obvious that both the College Yellow × Cuban Yellow single crosses and the predicted double crosses involving them had considerably higher percentages of stalk lodging than the single crosses and predicted double crosses involving only College Yellow germplasm. Stalk lodging, especially when it occurs early, is known to affect grain yield adversely.

Even though the predictions based upon the test of single crosses indicate that some College Yellow × Cuban Yellow double crosses would do well in a wet season, it might be well to resample both varieties and conduct the performance test under both wet- and dry-season conditions for several years. The other alternative is to sample other exotic varieties that are in the same latitudes as the Philippines, like Mexico and Colombia, for further improvement of corn yields. The Philippine Islands are within latitude 8° and 18° north of the equator. Havana, Cuba from which the Cuban Yellow variety was introduced, falls at about 23°N. A great portion of Colombia falls within latitude 15° to 23°N. Yield tests of these

new inbred-source materials in both seasons are necessary if their potentialities are to be judged most accurately. These more time-consuming steps can be taken when the rush to put out a reasonably high-yielding double cross for the corn growers ends and more funds to carry on such work become available.

LITERATURE CITED

EAST, E. M. 1936. Heterosis. Genetics **21**: 375-395.

ECKHARDT, R. C. and A. A. BRYAN. 1940. Effect of method of combining the four inbred lines of a double cross of maize upon the yield and variability of the resulting hybrid. Jour. Am. Soc. Agron. **32**: 347-353.

HAYES, H. K. and I. J. JOHNSON. 1939. The breeding of improved selfed lines of corn. Jour. Am. Soc. Agron. **31**: 710-724.

JENKINS, M. T. 1934. Methods of estimating the performance of double crosses in corn. Jour. Am. Soc. Agron. **26**: 199-204.

JOHNSON, I. J. and H. K. HAYES. 1940. The value in hybrid combinations of inbred lines of corn selected from single crosses by the pedigree method of breeding. Jour. Am. Soc. Agron. **32**: 479-485.

SNEDECOR, G. W. 1946. "Statistical methods." 4th ed. xvi + 485 pp. Ames, Iowa: Iowa State College Press.

WU, SHAO-KWEI. 1939. The relationship between the origin of selfed lines of corn and their value in hybrid combinations. Jour. Am. Soc. Agron. **31**: 131-140.

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Let the farmer forevermore be honored in his calling, for they who labor in the earth are the chosen people of God.

—*Jefferson*

COMPARATIVE STUDIES OF CABBAGE VARIETIES IN NUEVA ECIJA, MOUNTAIN PROVINCE, AND LAGUNA [1]

J. C. Acosta, A. Dimas, and T. G. Cadiz [2]

WITH ONE TEXT FIGURE

Test results indicated that O-S Cross, Succession, Copenhagen Market, Glory of Enkhuizen 505, Perfection Drumhead and Golden Acre (Yellow Resistant) cabbage varieties were suited to production at low elevations. O-S Cross was best of all in either high- or low-elevation culture. There was no correlation between vigor of plants and yielding ability of the varieties at the two elevations. Cabbage can be successfully grown anywhere in the Philippines during the cool months of the year.

Maturity of the varieties varied from 62 to 125 days after transplanting to the field and was earlier at low elevations than at high elevations. Furthermore, those raised at low elevations bore heads which were smaller and more compact.

There is need for more production of cabbage in the Philippines. Galang and Panganiban (1949) reported that during the five-year period preceding 1949 the imports averaged over 700,000 kilograms valued at about ₱120,000.00 yearly. This was increased considerably during the succeeding years.

Just after the war, some farmers in the Central Plain started to rotate cabbage with rice. The pre-war intensive production of this crop continued in Mountain Province.

At present unavailability of seed and lack of suitable variety seem to be the problems. To promote the industry, a government ban is now imposed on the importation of cabbage so that most of the supply comes from Mountain Province. All these point to the need for variety testing in the Central Plain or similar regions where cabbage can be grown commercially.

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When grown under favorable conditions cabbage is a very profitable crop. In places where the altitude is 700 to 2,000 meters the crop could be grown at any time of the year. At low elevation it grows best during the cool months from October to March.

Six experiments were conducted during the past three years in different areas to determine what varieties are best suited for production at low elevations (Bongabon, Nueva Ecija and College, Laguna), and at high elevations (La Trinidad, Mt. Province).

Rodrigo, Urbanes, and Olan (1938) reported that out of 19 varieties tested at Los Baños Economic Garden, Premier Flat Dutch, Late Flat Dutch, Solid South Surehead, Succession, Allhead Early, Charleston Wakefield, Enkhuizen Glory and Special Succession varieties were found best. They stated that from these results, other varieties would be adapted to the same conditions. They also conducted other trials in different stations during the dry and wet seasons. In the BPI Experiment Station, Manila, Special Succession, Late Flat Dutch, Succession, Autumn King, and Charleston Wakefield were found to be the best among 31 varieties tested. During a one-season test at the Alabang Station, Rizal, Succession and Copenhagen Market proved good. In the Lipa Coffee-Citrus Experiment Station, Batangas, Succession, Allhead Early, Charleston Wakefield, and Golden Acre were found to be the best among 10 varieties tested.

Rodrigo (1946), in his brief cultural directions for cabbage, reported that Special Succession, Succession, Allhead Early, Charleston Wakefield, Enkhuizen Glory, and Flat Dutch are heavy croppers in the lowlands.

With regards to yield and quality, Galang and Panganiban (1949) considered Special Succession, Late Flat Dutch, and Allhead Early the best. Of the 18 varieties introduced from Germany, the good yielders were Filder, Zlaco, Swedish, American, Hartmounts Earliest, Ironhead, Baby Savoy, and Succession.

Marcelo and Tolento (1950) reported that among the six varieties tested in Pili, Camarines Sur, Glory of Enkhuizen and All Season gave the best results.

MATERIALS AND METHODS

The seeds of the cabbage varieties were imported from different seed houses in the United States, Japan, and Europe. The strain number and corresponding source of each seed material are indicated

in the table for vigor in each experiment. Varieties that proved good in observational plantings at the College were included in the tests.

A 50:50 compost-fine sand mixture sterilized by heating to about 80°C for 30 minutes then placed in seed flats each having an inside dimension of about 16 × 12 × 3 inches was used for growing the transplants. In experiment II, however, a carefully prepared outdoor seedbed was used.

One week before the seedlings were set in the field, they were hardened by exposing the seed flats to the sun and providing only the minimum amount of water.

The land was plowed and harrowed twice using native animal-drawn implements in each planting except in experiments II and VI at La Trinidad where manual labor was used. Furrows were made for planting.

The varieties were completely randomized in replicated single-row plots at regular spacings except when specified otherwise.

The experiments conducted, their location, date of planting, number of replications and plot size are as follows:

EXPERIMENT NO.	NO. OF VARIETIES	LOCATION	DATE PLANTED	REPLICATION	PLOT *sq.m.*
I	10	College, Laguna	1/18/55	4	7
II	10	La Trinidad, Mt. Prov.	1/20/55	4	7
III	15	College, Laguna	12/27/55	2	10
IV	7	College, Laguna	1/23/57	2	7
V	9	Bongabon, Nueva Ecija	1/15/57	2	7
VI	9	La Trinidad, Mt. Prov.	1/16/57	2	7

Just before transplanting the properly hardened plants were watered, blocked, and then balled. A starter solution of two kilos of 12-24-12 complete fertilizer dissolved to every 50-gallon drum full of water was used for watering.

Experiments IV, V, and VI were in double-row plots 7 meters long. The hills were spaced 40 × 50 centimeters and the double rows from center to center were spaced 100 centimeters apart.

Aside from the starter solution the fertilizer applied was as follows:

Experiment I.—350 kilograms of ammophos applied 3 weeks after planting then side dressed at the same rate a month after.

Experiment II.—At each hill a handful of "Vigoro" plus compost (about 500 kg. and 5 tons per hectare, respectively), was added.

Experiments III and IV.—Seven hundred kg./ha. of 12-24-12 complete fertilizer was applied three weeks after planting.

Experiments V and VI.—No other fertilizer was applied.

Regular irrigation, weeding, and spraying were done in all locations. Control of pests was considered very satisfactory except in experiments I, II, V and VI where control with the use of Lexone, Marlate or Resitox was fair. In experiments III and IV where Endrin was used at 4.7 ml. to every gallon of water, pest control was effective.

Vigor, disease resistance, habit of growth, yielding ability and firmness of heads were recorded. Two to four months after transplanting, the plants were harvested. Firmness was judged subjectively by cutting longitudinally 3 heads and observing the compactness of the leaves.

RESULTS AND DISCUSSION

Habit of growth and vigor of plants. During the first few weeks there were no apparent differences among varieties but at the later stages approaching maturity the habit of growth and vigor of the different varieties became apparently distinct.

The seedlings in experiments I and II appeared to be purplish during germination, but this color disappeared a week later when the true pair of leaves developed. All of them grew rapidly a week after they were pricked. It was observed that O-S Cross, Succession, Copenhagen Market, Glory of Enkhuizen and Danish Ballhead were generally more vigorous than the other varieties (tables 1 and 3). Early Jersey Wakefield, Ferry's Round Dutch and Golden Acre had a lodging characteristic signifying poor root growth. The stocks of the Copenhagen Market 503, Copenhagen Market 1608, Golden Acre 50, and Ferry's Round Dutch 520 were fairly uniform; that of Copenhagen Market 53 was rugged.

Yield of marketable heads. Marketable heads were harvested such that about one or two leaves were to cover the head. The description of heads and weights in kilograms are presented in tables 2, 3 and 4.

The early-maturing varieties (Copenhagen Market 1608, Ferry's Round Dutch 520, Early Persey Wakefield 5080, and Golden Acre 50)

although small, produced desirable heads because they were compact and heavy. The differences in yield of the varieties in experiment 1 were not significant.

TABLE 1.—*Maturity, habit of growth and vigor of the plants at two locations, Experiments I & II*

VARIETY	SOURCE	COLLEGE, LAGUNA			LA TRINIDAD		
		Maturity [a]	Habit of growth [b]	Vigor [b]	Maturity	Habit of growth [b]	Vigor [b]
Copenhagen Market 53	Zwaan & de Wiljes Scheemda, Holland	71	5	2	101	2	2
Copenhagen Market 503	A. Cristensen Washington, U.S.	62	6	4	101	4	1
Copenhagen Market 1608	Ohlsens Enke, Denmark	62	9	8	81	7	8
Danish Ballhead 442	Ferndale, Washington, U.S.	110	10	9	125	10	10
Early Jersey Wakefield 5080	Lily Seed Co. Seattle, U.S.	71	1	5	81	1	9
Ferry's Round Dutch 520	A. Christensen, Washington, U.S.	80	2	1	81	5	4
Glory of Enkhuizen 505	A. Christensen, Washington, U.S.	80	8	10	101	9	7
Glory of Enkhuizen 2416	Ohlsens Enke, Denmark	92	3	3	101	6	5
Golden Acre 50 (Control)	Ohlsens Enke, Denmark	62	4	7	81	3	6
Racine Market 2153 A	Washington Cabbage Company, U.S.	71	7	6	101	8	3

[a] Number of days from transplanting to harvesting.
[b] 1, very poor; 5 & 6, fair; 10, excellent.

The Copenhagen strains in Trinidad Valley (Experiment II) differed significantly from each other in total weights in kilograms (table 5).

The performance of most varieties in experiment III was much better than in most lowland plantings because they were set early during the cool season, and had ample water and protection from insects.

Based on the actual weight of heads harvested from each plot, O-S Cross was the most outstanding variety. Differences in the mean yield of some of the different varieties were highly significant. O-S Cross was followed in descending order by Succession (a commercial variety grown in the country) Perfection Drumhead, Wisconsin Hollander, and Premium Flat Dutch (table 2). Cadiz *et al.* (1956) found

TABLE 2.—*Mean yield, weight per head and yield per hectare at low elevation, Experiment III*

VARIETY [a]	MEAN YIELD (12 m. row)	AV. MT. PER HEAD	TONS PER HA.	DESCRIPTION
	kg.	*kg.*	*tons*	
Copenhagen Market	11.19	.52	15.6	Round and medium firm
Enkhuizen Glory	13.93	.68	20.4	Oblong, medium firm
Premium Flat Dutch	16.52	.87	26.1	Flat and firm
Succession (Control)	20.09	.89	26.7	Flat, large, firm
Danish Roundhead	15.54	.72	21.6	Oblong, small, firm
Penn. State Ballhead	12.45	1.03	30.9	Large, round, firm
Wisconsin Hollander	17.68	.76	22.8	Round, firm
Early Jersey Wakefield	10.26	.61	18.3	Oblong, firm
O–S Cross	29.26	1.34	40.2	Flattish, large, medium firm
Burpee Allhead Early	14.72	.77	23.1	Round, small, firm
Perfection Drumhead	19.74	.94	28.2	Large, flat, firm
Mammoth Red Rock	10.92	.47	14.1	Oblong, red, very firm
Golden Acre	9.90	.52	15.6	Oblong, small, firm
Marion Market	14.38	.63	18.9	Round, small, firm
Bonanza	12.26	.60	18.0	Round, small, firm

S.M.D. (V) at 5% = 5.62
1% = 7.80

[a] Most of the seeds were obtained from Ferry Morse, Northrup King, Burpee, Keystone, Robinson, Robson and Kilgore Seed Co. in the United States.

TABLE 3.—*Vigor and description of plants at two locations, Experiments V & VI*

VARIETY [a]	BOÑGABON, N. ECIJA [b]		MATURITY (*days*)	LA TRINIDAD, MT. PROV.		MATURITY (*days*)
	Vigor [c]	Description		Vigor [c]	Description	
All Season	3	Not uniform, firm heads	80	3	Not uniform, not firm	100
Golden Acre	2	Small plants very firm	65	3	Uniform, not firm	80
Bonanza	3	Not uniform, firm	70	3	Fairly uniform, not firm	90
Copenhagen Market	4	Not uniform, firm	65	4	Uniform, fairly firm	80
Enkhuizen Glory	4	Fairly uniform, firm	80	3	Fairly uniform, not firm	100
Golden Acre (Y.R.)	3	Uniform, fairly firm	65	4	Uniform, not firm	80
Steins' Early Flat Dutch	4	Not uniform, leafy, fairly firm	85	3	Uniform, not firm	100
O–S Cross	5	Uniform, vigorous, firm	80	4	Uniform, not firm	90
Succession (Control)	4	Fairly uniform, firm	75	4	Fairly uniform, not firm	90

[a] All seeds were obtained from Burpee Seed Co.
[b] Vigor and compactness of heads were very similar in Bongabon and College.
[c] 1, very poor; 3, fair; 5, excellent.

TABLE 4.—*Mean yields in kilograms* [a] *at three locations and computed yield per hectare, Experiments IV, V & VI*

VARIETY	LOCATION			TONS PER HECTARE		
	College	Boñgabon	La Trinidad	College	Boñgabon	La Trinidad
	kg.	*kg.*	*kg.*			
All Season	—	2.37	3.55	—	11.8	17.7
Golden Acre	5.79	2.68	3.96	17.4	13.4	19.8
Bonanza	6.11	4.15	3.18	18.3	20.8	15.9
Copenhagen Market	8.04	4.21	3.82	24.1	21.1	19.1
Enkhuizen Glory	7.00	3.89	3.27	21.0	19.4	16.4
Golden Acre (Yellow Resistant)	7.81	3.38	3.96	23.4	16.9	19.8
Steins' Early Flat Dutch	—	3.81	2.94	—	19.1	14.7
O–S Cross	10.34	4.49	6.02	31.0	22.4	30.0
Succession (Control)	6.73	2.68	3.30	20.2	13.4	16.5
S.M.D. (V) at 5% =	NS	0.95	1.42			
1% =	NS	NS	NS			

[a] Averages of 10 heads for College; 6 for Bongabon; 6 for La Trinidad.

TABLE 5.—*Mean weight of ten heads in kilograms of cabbage varieties and strains planted at two locations, Experiments I & II*

VARIETY	COLLEGE	LA TRINIDAD	COMPUTED YIELD PER HECTARE (tons)	
			College	La Trinidad
Copenhagen Market 53	2.15	13.48	5.38	33.69
Copenhagen Market 503	1.25	9.65	3.12	24.12
Copenhagen Market 1608	2.23	4.78	5.56	11.94
Danish Ballhead 442	2.35	10.38	5.87	25.94
Early Jersey Wakefield 5080	2.48	5.98	6.19	14.94
Ferry's Round Dutch 520	2.18	6.50	5.44	16.25
Glory of Enkhuizen 505	3.65	13.18	9.12	32.94
Glory of Enkhuizen 2416	2.60	14.53	6.50	36.31
Golden Acre 50 (Control)	2.33	6.43	5.81	16.06
Racine Market 2153 A	2.23	8.73	5.56	21.81
S.M.D. (V) at 5% =	NS	2.25		
1% =	NS	3.05		

that O-S Cross, the best variety, appeared as uniform and as vigorous as it does under the most favorable growing condition in the United States.

Variance due to interaction of variety with locality was computed for experiment IV (Bongabon) and experiment V (La Trinidad).

O-S Cross far out-yielded most of the varieties. Copenhagen Market was a far second followed by Bonanza, Golden Acre (Yellow Resistant), and Glory of Enkhuizen. All Season was the poorest.

The interactions between replications × variety and variety × location were not significant. This indicates that the high yielding varieties maintained their capacity in all replications and locations.

The analysis of variance in experiment IV showed that there were no significant differences among varieties although the O-S Cross was the best yielder with an average head weight of 1.03 kg. and Golden Acre, the poorest with .57 kg. (table 4).

In experiment II there was much variability in vigor. Succession, Premium Flat Dutch and Perfection Drumhead produced many large leaves but the heads were small.

Maturity. Estimates of the maturity of the different varieties are presented in tables 1 and 3. Cabbage grown at low elevations matured earlier than those produced at high elevations by about 20 days. Comparisons of experiment I with II then with IV, V and VI would show these observations. The varieties at Los Baños matured in 62 to 110 days but those in La Trinidad, 81 to 125 days. Bonanza, Copenhagen Market and Golden Acre strains were the earliest maturing in all the varieties tested in both low and high elevations. Enkhuizen Glory, Allhead Early, Mammoth Red Rock, Penn. State Ballhead, Wisconsin Hollander and O-S Cross were medium maturing whereas Perfection Drumhead and Danish Ballhead were late maturing.

Quality of heads. With regards to the general appearance of the heads, (experiments I, II, IV and VI) Glory of Enkhuizen 505 was the best, followed by Early Jersey Wakefield 5080. The rest of the varieties were similar except for the Copenhagen strains which were more severely attacked by insects.

In experiment III, O-S Hybrid produced big heads which were flattish or disc-shaped, attractive and fairly compact. Most varieties produced heads which were attractive and firm (table 2).

Observations in experiments IV, V and VI indicated that heads produced at low elevations were firmer than those grown at high elevations. Representative heads of the 7 varieties planted at College (experiment IV) are shown in figure 1.

All the varieties grown in Mountain Province were not very compact but the heads were bigger.

Fig. 1.—Representative heads and longitudinal sections of the seven varieties planted at College, Laguna. 1, Golden Acre (Y.R.); 2, Copenhagen Market; 3, Enkhuizen Glory; 4, O-S Cross; 5, Bonanza; 6, Succession; 7, Golden Acre. (*Photograph taken by the Photographic Division.*)

Insects and diseases. The Copenhagen varieties in experiments I and II were susceptible to cabbage worm (*Crocidolomia binotalis* Zeller). The other insects found feeding on the plants were cutworm (*Prodenia litura* Fabr.) *Plusia chalcytes* Esper., *Phaneroptera furcifera Stal.* and the cabbage aphids (*Aphis brassicae* Linn.)[3] These insects were controlled by spraying or dusting twice a week with Lexone or Marlate at 60 grams per 3 gallons by a knapsack sprayer. Sometimes a mixture of 50:50 Lexone and Marlate or 50:50 Zerlate and Marlate was sprayed on the plants.

The Copenhagen Market 503 and the Early Jersey Wakefield 5080 seedlings were attacked by damping-off disease caused by *Phythium debaryanum Hesse.* The Racine Market 2153A and the Copenhagen varieties were attacked by *Fusarium* wilt caused by a species of *Fusarium.* Spoiling probably due to heat was observed in the Early Jersey Wakefield. Head rot (*Erwinia carotovora* Jones)[4] was also found in some varieties but the damage was not very severe.

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[3] All these insects were identified by Dr. S. M. Cendaña of the Department of Entomology.

[4] These diseases were identified by Assistant Professor V. M. Ela of the Department of Plant Pathology.

Pulling out the diseased seedlings and spraying or dusting the plants with Zerlate were used as control measures.

In experiments III and IV, Endrin at the rate of 4.7 ml./gallon was sprayed every two weeks during the growing season. Insects were kept well under control and as a result attractive heads were harvested. As in experiments I and II the same insect pests and diseases were found attacking the plants.

In the experiments at Bongabon and La Trinidad the farmer-cooperators used Resitox as spray 3 times during the growing period of the plants. Insects were not well controlled. However, damage was not too severe.

LITERATURE CITED

CADIZ, T. G., T. L. YORK, and J. C. ACOSTA. 1956. Vegetable experiments at Los Baños. Agricultural and Industrial Life Magazine **18**: 24-25; 37; 52.

GALANG, F. G. and F. C. PANGANIBAN. 1949. Agricultural Extension Handbook. Manila: Bureau of Printing, 336 p.

MARCELO, P. B. and F. TOLENTO. 1950. Plant Industry Digest. **13**: (2), 19.

RODRIGO, P. 1946. Plant Industry Digest. **9**: (2), 11.

————, P. S. URBANES, and U. R. OLAN. 1938. Philippine Journal of Agriculture **9**: 1.

WORK, P. and J. CAREW. 1955. Vegetable production and marketing. 2nd ed. New York: John Wiley & Sons, Inc.

THOMPSON, H. C. 1949. Vegetable crops. 4th ed. New York: McGraw-Hill Book Co., Inc.

SOME ORGANIC INSECTICIDES IN THE CONTROL OF THE CORN EARWORM AND THE CORN BORER ON GREEN CORN [1]

G. B. Viado, A. F. Banaag, and R. A. Luis [2]

The percentage of sound husked ears was much higher than that of the unhusked ears, indicating that many of the earworm and borer injuries to the unhusked ears did not reach the kernels.

During the rainy season most of the injuries to the ears were caused by earworms and during the dry season, by borers.

Of the seven insecticides tested, DDT emulsion was the best. A 50-50 mixture of DDT emulsion at 3 quarts and Endrin at 1 pint was more effective than either DDT at 6 quarts or Ryania at 6 pounds.

In all the three tests, DDT alone or combined with Endrin gave the best control.

The higher income derived from green corn as compared to field corn has given impetus to the production of this commodity by corn farmers in some sections of the country.

Not all corn varieties are suitable for green corn. One that commands a high price in the market is a glutinous variety known locally as "Lagkitan." This variety, however, is very susceptible to the ravages of the corn earworm, *Heliothis armigera* (Hubner) and the cornstalk borer, *Pyrausta salentialis* (Snellen). At times 50 per cent or more of the ears are rendered unmarketable by these insects.

The use of chemicals for the field control of insects affecting corn in the Philippines is not practised to any extent. Tests have shown that some insecticides are effective against some insects affecting corn. Banaag and Viado (1954) found DDT and Dieldrin effective against the earworm and the stalk borer on field corn. To find out if organic insecticides are effective against these pests in this country, this study was conducted from May, 1956, to October, 1957, at the Central Experiment Station, U.P. College of Agriculture.

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[1] Central Experiment Station Contribution No. 1956.

[2] The authors acknowledge the help of Dr. R. W. Dean, former Cornell Visiting Professor of Entomology, in planning one of the tests in this project.

MATERIALS AND METHODS

Three separate tests covering the two crop seasons of the year were conducted, the first in the 1956 rainy season, the second in the 1956-1957 dry season and the third in the 1957 rainy season.

"Lagkitan" seed was used in all the tests. Five randomized blocks each consisting of 5 to 6 plots provided with a guard row between each plot were used. The blocks and plots in each test were staked and labeled after the field was planted. Missing hills were replanted five days after planting. Agronomic practices involved in the culture of field corn were observed in the tests. The first insecticide application was done before soil emergence. The insecticides, formulations, dosages or amount of the chemical per 100 gallons of spray, and number and interval of application in the three tests were as follows:

TEST 1. Rainy season (June 22 to Sept. 11, 1956)
Plot size: 10 m x 6 m
5% DDT dust
25% DDT emulsifiable concentrate ..... 2 quarts
25% EPN wettable powder ..... 4 pounds
19.5% Endrin emulsifiable concentrate .... 2 quarts
Number of applications 3
Interval of application ..... 5 days

TEST 2. Dry season (Nov. 14, 1956 to Jan. 22, 1957)
Plot size: 10 m x 5 m
25% DDT emulsifiable concentrate ..... 6 quarts
25% DDT emulsifiable concentrate ..... 3 quarts
95.8% Ryania ("Ryanexel") ..... 6 pounds
25% Rhothane emulsifiable concentrate ... 3 quarts
19.5% Endrin emulsifiable concentrate ... 2 quarts
Number of applications 4
Interval of application ..... 3 days

TEST 3. Rainy season (June 6, 1957 to Aug. 10, 1957)
Plot size: 11 m x 6 m
50% Guthion emulsifiable concentrate .... 1 pint
50% Dipterex emulsifiable concentrate .... 1 pint
25% DDT emulsifiable concentrate ..... 6 quarts
95.8% Ryania ("Ryanexel") + sticker ("Tenac")[4] ..... 6 pounds
25% DDT emulsifiable concentrate plus ... 3 quarts

[4] The sticker was used at the rate of 1 ml. per gallon of spray.

19.5% Endrin emulsifiable concentrate .... 1 pint
Number of applications 4
Interval of application ..... 3 days

Compression hand sprayers each with a capacity of 3½ gallons were used. A small rotory hand duster ("Kyoritu") with a capacity of about 130 grams of dust was used for spraying DDT. Only the ear and part of the stem at the base of the ear of the plant was treated. Sprayings were done in the morning.

RESULTS AND DISCUSSION

External injury by the corn earworm on unhusked ears is difficult to detect, especially when the larva entered the ear while still small. The injury caused by a young larva to the silk is nil. Borer injury, on the other hand, is easily detected because of the characteristic hole the insect bores into the ear through the husk. Sometimes the borer in the stalk finds its way into the ear through the peduncle.

Effects on the percentage of undamaged ears. Test 1 results show considerable differences between treatments (table 1). In the unhusked ears, the treatments increased significantly the percentage of sound ears over the control. That which gave the highest percentage of sound ears was DDT emulsion, followed by Endrin, EPN, and DDT dust. In the husked ears, treatments increased significantly the percentage of sound ears over the control at the five per cent level. The best treatment was Endrin, followed by DDT emulsion, EPN, and DDT dust.

In the second test, treatments increased significantly the percentage of sound unhusked ears over the control at the five per cent level (table 2). The best treatment was DDT at 6 quarts, followed by Rhothane, Ryania, DDT at 3 quarts, and Endrin. In the husked ears, the increase over the control was significant at one per cent level. The treatment which gave the highest percentage of sound ears was DDT at 6 quarts, followed by DDT at 3 quarts, Ryania, Rhothane, and Endrin.

The treatments in the third test increased significantly the percentage of sound unhusked ears over the control (table 3). The best was a mixture of DDT and Endrin, followed by DDT alone, Ryania and sticker, Dipterex, and Guthion.

TABLE 1.—*Mean percentage of damaged ears in the different treatments (Rainy season, 1956)*

TREATMENT	UNHUSKED				HUSKED					
	Damaged		Damaged by borer		Damaged		Damaged by earworm		Damaged by borer	
	Actual	Angle	Angle	Actual	Actual	Angle	Actual	Angle	Actual	Angle
DDT, dust	33.84	35.56	27.81	31.62	16.54	23.73	11.23	19.50	7.55	15.44
DDT, EC	24.23	29.36	20.47	26.73	11.13	19.30	8.17	16.48	3.76	10.69
EPN	29.33	32.73	20.12	26.53	14.33	22.03	10.18	18.55	4.38	11.61
Endrin	26.56	30.79	17.31	23.70	10.16	17.39	9.43	17.26	3.00	9.56
Control	56.33	48.78	50.44	45.27	29.97	32.63	21.97	27.71	11.49	19.14
S.M.D. (T) at 5%		6.98		9.06		8.54		4.46		6.15
1%		9.61		12.49		[a]		6.26		[a]

[a] Insignificant.

TABLE 2.—*Mean percentage of damaged ears in the different treatments (Dry season, 1956-1957)*

TREATMENT	EARWORM				BORER			
	Unhusked		Husked		Unhusked		Husked	
	Actual	Angle	Actual	Angle	Actual	Angle	Actual	Angle
DDT, 6 quarts	1.83	7.56	1.55	6.94	3.25	10.16	0.72	3.43
DDT, 3 quarts	4.02	11.26	2.72	9.14	3.73	10.98	1.02	5.68
Ryania	3.68	10.60	2.14	8.16	5.20	12.94	3.42	10.20
Rhothane	5.76	13.42	2.40	8.63	6.97	14.71	3.48	10.38
Endrin	6.27	13.91	4.20	11.38	8.29	15.42	3.64	10.60
Control	7.08	15.18	6.80	14.91	16.24	23.57	8.34	16.62
S.M.D. (T) at 5%		3.17		4.15		4.67		3.42
1%		4.29		[a]		6.32		4.62

[a] Insignificant.

TABLE 3.—*Mean yield of the different treatments in kilograms of sound ears (Rainy season, 1957)*

TREATMENT	REPLICATION					TOTAL	MEAN
	I	II	III	IV	V		
Guthion	9.2	13.1	14.9	7.9	7.8	52.9	10.58
Dipterex	10.0	22.5	11.4	15.5	14.1	73.5	14.70
DDT	32.0	31.6	28.9	9.9	14.1	116.5	23.30
DDT + Endrin	32.1	26.5	28.8	13.1	23.2	123.7	24.74
Ryania + sticker	14.6	14.1	12.7	15.8	2.9	60.1	12.02
Control	7.7	6.8	8.7	2.6	0.7	26.5	5.30
Total	105.6	114.6	105.4	64.8	62.8	453.2	
S.M.D. (T) at 5% = 6.83							
1% = 9.31							

In all the tests, the percentage of sound husked ears was much higher than that of the unhusked ears. The highest percentage of sound unhusked ears was effected by a 50-50 mixture of 25 per cent DDT emulsifiable concentrate at the rate of 3 quarts per 100 gallons of water and 9.5 per cent Endrin emulsifiable concentrate at the rate of one pint per 100 gallons. The next best was DDT emulsifiable concentrate at 6 quarts per 100 gallons.

Effects on the percentage of ears damaged by earworm and borer. In the first and third tests most of the injury to the ears was caused by earworms; in the second test, by borers.

In the first test, the mean percentages of ears damaged by earworm in husked ears varied in the different treatments (table 1). The treatments reduced significantly the percentage of damaged ears over the control. That which gave the least percentage of damaged ears was DDT emulsion, followed by Endrin, EPN, and DDT dust. The treatments reduced significantly the percentage of unhusked ears damaged by borer. The best was Endrin, followed by EPN and DDT emulsion. The poorest was DDT dust. In the husked ears damage reduction was significant at the five per cent level. The best treatment was Endrin, followed by DDT emulsion, EPN, and DDT dust. There was a higher percentage of husked ears injured by earworm than by borer.

There was significant reduction of earworm damage in all the treatments in the second test (table 4). The best was DDT 6 quarts, followed by Ryania, DDT 3 quarts, Rhothane, and Endrin. In the husked ears, all the treatments reduced significantly the earworm infestation over the control at the five per cent level. DDT 6 quarts was the best followed by Ryania, Rhothane, DDT 3 quarts, and Endrin. There was a higher incidence of borer infestation in the unhusked ears in the second test than that of the earworm. All the treatments reduced significantly the borer damage over the control. DDT 6 quarts gave the greatest reduction followed closely by DDT 3 quarts, then Ryania, Rhothane, and Endrin. In the husked ears, the treatments reduced significantly borer infestation over the control. The best was DDT 6 quarts, followed by DDT 3 quarts, Ryania, Rhothane, and Endrin.

TABLE 4.—*Mean percentage of ears damaged by earworm and borer in the different treatments (Rainy season, 1957)*

TREATMENT	EARWORM				BORER			
	Unhusked		Husked		Unhusked		Husked	
	Actual	Angle	Actual	Angle	Angle	Angle	Actual	Actual
Guthion	61.38	51.65	4.07	11.42	4.49	11.32	0.86	4.11
Dipterex	52.46	46.54	2.10	7.22	4.84	11.52	1.09	5.16
DDT	23.14	27.91	0.24	1.26	0.58	2.58	0	0
DDT + Endrin	16.79	23.92	0.35	1.50	0	0	0	0
Ryania + Sticker	49.48	44.75	4.46	11.75	3.24	8.79	0.61	3.89
Control	83.49	66.70	11.77	19.91	9.60	17.68	3.33	9.17
S.M.D. (T) at 5%	6.34		4.36		4.99		4.49	
1%	8.64		5.95		6.81		6.12	

In the third test, the damage caused by earworms in the unhusked ears was reduced significantly over the control by the treatments (table 4). The DDT and Endrin mixture was best followed by DDT, Ryania and sticker, Guthion, and Dipterex. Earworm injury in the husked ears was also significantly reduced in all the treatments. The most effective was DDT, closely followed by the DDT and Endrin mixture. The third best was Dipterex, followed by Guthion and Ryania and sticker. There was higher incidence of earworm than borer injury in this test. In the unhusked ears, the treatments reduced significantly the percentage of ears damaged by borer over the control. The best was the mixture of DDT and Endrin in which no ear was damaged by borer. DDT was next, followed by Ryania and sticker, Guthion, and Dipterex. The treatments reduced significantly the percentage of husked ears damaged by borer over the control.

Effects on the yield. The treatments increased significantly the yield in kilograms of sound ears over the control. That which gave the highest yield was the DDT and Endrin mixture closely followed by DDT, then Dipterex, Ryania and sticker, and Guthion. The sequence follows more or less that of the yield in percentage of sound ears.

DDT emulsion was the most effective of the insecticides tested against the earworm. Banaag and Viado (1954) also found DDT most effective of the insecticides they tested against earworm on field corn. Several investigators, most of them working on sweet corn, reported the effectiveness of DDT emulsion over other insecticides against this pest in the United States (Anderson *et al.*, 1949, 1951a, 1951b; Bacon, 1950; Bacon *et al.*, 1953; Blanchard and Chamberlin, 1948; Blanchard *et al.*, 1955; Butler and Carruth, 1949a; Douglas and Smith, 1953; Eden, 1952, 1953, 1956; Hayslip, 1949; Hayslip *et al.*, 1953; Howe and Davis, 1954; Kulash, 1948, 1950; Liederman, 1954; Liederman and Sauer, 1953; Rutschky, 1951; Thames, 1952; Wilson, 1955). Dusts containing three to five per cent DDT were also reported effective against earworm on sweet corn (Anderson *et al.*, 1951b, 1952; Butler and Carruth, 1945-b; Kelsheimer, 1947; Kelsheimer, *et al.*, 1950; Pond, 1955). In the present study, however, five per cent DDT was not effective. Wene and Blanchard (1950) also found that in Texas, periodic dusting with DDT failed to give commercial control of earworm attacking the ears. Against the corn borer, Apple and Decker (1950), Decker (1947), Ditman (1950), and Turner (1945) found DDT effective.

In the second test, although DDT at 6 quarts gave the best control against earworm, Rhothane was superior to DDT at equal level (3 quarts per 100 gallons of water). Rhothane was reported by some investigators almost or as effective as DDT against earworm (Anderson and Hashe, 1949; Blanchard and Chamberlin, 1948; Blanchard *et al.*, 1955). Others, like Bacon *et al.* (1953), Kulash (1948, 1950), and Pond (1955), reported good control of earworm with this chemical. Against the corn borer, Apple and Decker (1950) found it as effective as DDT.

Ryania showed some effectiveness against the earworm and the borer. At 6 pounds per 100 gallons of water, it was more effective against earworm than DDT at 3 quarts, Endrin at 2 quarts, Dipterex at 1 pint, and Guthion at 1 pint. Kulash (1948) and Pond (1955) reported good control against earworm with this incesticide. Decker (1947) and Turner (1945) found Ryania effective against the borer.

Endrin was inferior to DDT, Rhothane, and Ryania against the earworm, but a 50-50 mixture of DDT at 3 quarts and Endrin at 1 pint was superior to DDT at 6 quarts. However, some investigators reported Endrin as an effective insecticide against the earworm (Bacon *et al.*, 1953; Blanchard *et al.*, 1955; Howe and Davis, 1954; Liederman, 1954).

LITERATURE CITED

Anderson, Lauren D. and James W. Hashe. 1949. Studies on control of corn earworm on sweet corn in southern California. Jour. Econ. Entom. **42**: 933-941.

Anderson, L. D., H. T. Reynolds, J. W. Hashe, and J. E. Swift. 1951a. Studies on control of corn earworm on sweet corn in southern California in 1949. Jour. Econ. Entom. **44**: 905-909.

Anderson, L. D., O. G. Bacon, H. T. Reynolds, and J. E. Swift. 1951b. Investigations of corn earworm control on sweet corn in California in 1950. Jour. Econ. Entom. **44**: 966-971.

Anderson, L. D., O. G. Bacon, J. E. Swift, and H. T. Reynolds. 1952. Corn earworm control on sweet corn. California Agriculture **6**: 8, 9, 15.

Apple, J. W. and G. C. Decker. 1950. Corn borer control on sweet corn with concentrated sprays. Jour. Econ. Entom. **43**: 364-371.

Bacon, Oscar G. 1950. Control of corn earworm on sweet corn in northern California. Jour. Econ. Entom. **43**: 364-371.

Bacon, O. G., L. D. Anderson, and H. T. Reynolds. 1953. Control of corn earworm attacking sweet corn in California. Jour. Econ. Entom. **46**: 614-620.

Banaag, Avelino F. and G. B. Viado. 1954. Tests of five insecticides in the control of insects affecting corn. Philippine Agriculturist **38**: 419-434.

BLANCHARD, R. A. AND T. R. CHAMBERLIN. 1948. Tests of insecticides, including DDT, against the corn earworm and the fall armyworm in corn. Jour. Econ. Entom. **41**: 928-935.

BLANCHARD, R. A., GEORGE W. WENE, W. A. DOUGLAS, AND HARRY K. GOUCK. 1955. Insecticides in mineral oil emulsions for control of the corn earworm and fall armyworm in sweet corn. Jour. Econ. Entom. **48**: 714-718.

BUTLER, JR., GEORGE D. AND L. A. CARRUTH. 1949a. Corn earworm control with DDT and other insecticides. Jour. Econ. Entom. **42**: 457-461.

———. 1949b. Corn earworm control with insecticidal dusts on western Long Island, 1949. Jour. Econ. Entom. **42**: 930-933.

DECKER, GEORGE C. 1947. What chemicals for corn borer control. Agric. Chemicals **2**: 20-24.

DITMAN, L. P. 1950. Control of corn earworm and other pests of corn. Jour. Econ. Entom. **43**: 191-193.

DOUGLAS, W. A. AND C. E. SMITH. 1953. Control of corn earworm and rice weevil in dent corn with DDT-mineral oil emulsions. Jour. Econ. Entom. **46**: 683-684.

EDEN, W. G. 1952. Control of corn earworm in sweet corn in Alabama. Jour. Econ. Entom. **45**: 105-108.

———. 1953. DDT for earworm control in sweet corn. Jour. Econ. Entom. **46**: 359-360.

———. 1956. Experiments on earworm control on sweet corn. Jour. Econ. Entom. **49**: 822-825.

HAYSLIP, NORMAN C. 1949. The present status of sprays and dusts for the control of insects attacking the ears of sweet corn. Proc. Florida State Hort. Soc. **62**: 127-130.

HAYSLIP, N. C., E. G. KELSHEIMER, W. H. THAMES, JR., AND J. W. WILSON. 1953. Corn earworm investigations in Florida. Jour. Econ. Entom. **46**: 574-582.

HOWE, ROBERT G. AND A. C. DAVIS. 1954. Corn earworm control on Long Island. Jour. Econ. Entom. **47**: 94-97.

KELSHEIMER, E. G. 1947. The use of some organic insecticides in the control of earworm attacking sweet corn. Proc. Ann. Meet. Florida State Hort. Soc. **60**: 121-123.

KELSHEIMER, E. G., N. C. HAYSLIP, AND J. W. WILSON. 1950. Control of budworms, earworms and other insects attacking sweet corn and green corn in Florida. Florida Agric. Expt. Sta. Bull. 466.

KULASH, WALTER M. 1948. New insecticides for corn earworm control. Jour. Econ. Entom. **41**: 387-389.

———. 1950. Further tests for earworms control in sweet corn. Jour. Econ. Entom. **43**: 430-432.

LIEDERMAN, L. 1954. New results in the control of the corn earworm. Biologico (Sao Paolo) **20**: 131-137.

LIEDERMAN, L. AND H. F. G. SAUER. 1953. Effects of insecticides on corn earworm. Biologico (Sao Paulo) **19**: 137-143.

POND, D. D. 1955. Insecticides against the corn earworm in New Brunswick. Jour. Econ. Entom. **48**: 198-199.

RUTSCHKY, CHARLES W. 1951. Corn earworm control experiments in Pennsylvania in 1950. Jour. Econ. Entom. **44**: 567-569.

THAMES, WALTER H., JR. 1952. Corn earworm control—timing and number of applications. Florida Entom. **35**: 47-50.

TURNER, NEELY. 1945. Some fundamental aspects of control of the European corn borer. Connecticut State Agric. Expt. Sta. Bull. 495, 43.

WENE, GEORGE AND R. A. BLANCHARD. 1950. Insecticide dusts for control of the corn earworm. Jour. Econ. Entom. **43**: 1-4.

WILSON, JOHN W. 1955. Control of the corn earworm in Florida. Jour. Econ. Entom. **48**: 442-444.

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The farmer stands to lose in this world of competitive economy if he is not supported by a full-fledged program of research that looks into every nook and cranny of his enterprise and tries to bring about methods of production and distribution that will mean a continuous profit to him.

—*C. R. Orton*

MEASUREMENT OF CONSUMPTIVE USE OF WATER BY LOWLAND RICE [1]

A. P. Aglibut, A. B. Catambay,
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The quantity of water required by a lowland rice crop varies according to variety, soil, climate and use and management of irrigation. If this amount is entirely supplied by irrigation, it is called irrigation requirement. The amount of water needed in the processes of plant growth and the amount lost through evaporation are collectively called evapotranspiration, or consumptive use of water.

Evapotranspiration in lowland rice has been measured by some irrigation specialists. From his studies at the Kyushu Agricultural Experiment Station, Sato (1954) reported that lowland rice plants use 5.0 mm. to 7.0 mm. of water per day in midsummer and 5.0 mm. to 5.8 mm. per day in autumn. He also reported decreasing transpiration rates as the plants grew and developed to maturity. From India, Singh *et al.* (1935) reported four stages of high water needs of rice, namely: the seedling stage, the pre-flowering and flowering stages, and stage of grain formation. Van de Goor (1950) also reported the varying water use at different stages of lowland rice growth.

This study was conducted at the UP College of Agriculture and Central Experiment Station to determine (1) the consumptive use of water (evapotranspiration) by Milfor 6 (2) in the course of its growth, (2) the developmental stages of the rice variety when water use is high, (3) the consumptive use and transpiration ratios and, (4) the average daily consumptive use during the crop season.

MATERIALS AND METHOD

The method used in this experiment was similar to that of Sato (1954), and the equipment used consisted of three 3-tank sets.

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[2] Research Associate Professor of Agricultural Engineering; Professor of Agricultural Engineering and Head, Department of Agricultural Engineering; Cornell Visiting Professors for 1956-1957 and 1954-1956. The authors are grateful to the Statistical Service and Computing Section for the computations and to former research assistants Dante de Padua and B. G. Valdez for their assistance in collecting the data.

The tanks in each set were designated as tank A for measuring evaporation; tank B, for evapotranspiration, and tank C, for evapotranspiration and percolation. Since the three tanks in each set were the same in area and planted with equal number of hills and equal number of seedlings of the same variety per hill, the evaporations from each tank in a set were assumed as the same. Transpiration was obtained by subtracting the evaporation obtained in tank A from the readings taken from tank B. Percolation was the difference between the readings of tanks C and B. Table 1 shows the designation, dimensions, description and use of each tank.

TABLE 1.—*Description of experimental tanks*

SET NUMBER	TANK DESIGNATION	INSIDE DIMENSIONS CENTIMETERS $L \times W \times D$	MAKE, DESCRIPTION AND USE
I	A	90 × 90 × 15	Metal, with tubes for plants soldered to tight bottom; measures evaporation
	B	90 × 90 × 90	Metal with tight bottom; measures evapotranspiration
	C	90 × 90 × 90	Metal, without bottom; measures evapotranspiration and percolation
II	A	The same as I-A	The same as I-A
	B	The same as I-B	Concrete with bottom and has the same use as I-B
	C	The same as I-C	Concrete, without bottom and has the same use as I-C
III	A	The same as II-A	The same as II-A
	B	The same as II-B	The same as II-B
	C	The same as II-C	The same as II-C

The B tank in set I was shaped according to the given dimensions, soldered, painted with red lead paint and hot asphalt, and then placed in the ground after excavating the soil. The tanks were set to a depth such that their rims were 15 centimeters above the soil surface. The excavated soil was placed back in the tank in almost the same profile as when it was removed. This detail was also observed in placing back the soil after the concrete tanks B of sets II and III had sufficiently hardened. Tank C of set I was set after a columnar earth that fitted with the inside dimension of the tank had been excavated around. The tanks C in sets II and III were poured in place after a four-inch trench around the column of earth had been excavated. All the concrete tanks were reinforced with steel bars.

Glass gauges for measuring the drops of the water levels in the tanks were set with an inclination that made the readings on the gauges 10 times the actual vertical drop of water level in the tanks. The vertical drop of water level in each tank due to evapotranspiration between two successive observations was one-tenth of the difference between the two corresponding gauge readings.

The gauges were read three times a day, at 7:00 o'clock in the morning, 12:00 noon and 4:00 o'clock in the afternoon. Every tank was refilled to the original depth of 5 centimeters after taking the morning reading of each gauge. Excessive use of water required oftener refilling of the tanks. After heavy rains the water levels in the tanks were re-set on the gauges by removing the additional water from the rains.

RESULTS AND DISCUSSION

Weekly and daily consumptive use. The weekly consumptive use of Milfor 6(2) was measured by the B tanks during the period of continuous submergence. This period started from the third week after transplanting and ended two weeks before harvesting. Submergence depth of 5 centimeters in the tanks was used. This depth was found most economical by Aglibut and Hoff (1955) who reported a lack of significant difference in yields of each of three rice varieties with the use of 5, 10, and 15 centimeters of continuous and intermittent submergence. Table 2 shows the average weekly and daily consumptive use during the period of observation. From the three tests, the average weekly and daily consumptive use for the season (excluding rainfall) were 4.15 centimeters and 0.59 centimeters. This average daily consumptive use was slightly higher than that observed by Sato (1954). The total depth of water used by evapotranspiration and average daily use are also shown in the table. By using the overall weekly and daily average water use values, the total evapotranspiration for longer periods of observation can be determined.

Comparative values of evaporation and transpiration. Table 3 shows the comparative values of evaporation and transpiration and their average weekly and daily rates during the different stages of growth and development of the rice plants. From the overall weekly and daily average rates of evaporation and transpiration, a ratio of 1.31 between the two quantities was determined. The reciprocal of the ratio of the evaporation and transpiration shows that Milfor 6(2), if grown under conditions similar to those obtaining

TABLE 2.—*Consumptive use of water by lowland rice from three tests*

WEEK AFTER TRASPLANTING	WEEKLY AND DAILY CONSUMPTIVE USE OF WATER BY MILFOR 6(2) FROM THREE TESTS				
	1	2	3	Average	
				Weekly	Daily
	Centimeters				
3rd	4.62	3.02	2.58	3.41	0.49
4th	4.82	2.37	3.19	3.46	0.49
5th	3.48	4.13	4.23	3.95	0.56
6th	4.84	5.22	2.50	4.19	0.60
7th	4.66	4.10	4.44	4.40	0.60
8th	4.76	3.34	3.43	3.84	0.55
9th	5.72	4.38	4.78	4.96	0.71
10th	5.04	5.22	6.20	5.49	0.78
11th	2.22	3.15	3.50	2.96	0.42
12th	6.53	5.29	4.19	5.34	0.76
13th	2.70 [7a]	1.98 [4a]	2.73 [4a]	3.53	0.50
Total	49.39	42.20	41.77	4.15/week	—
Average	0.64	0.55	0.54		0.59

[a] 4, 7—Number of days included in the terminal week of observation. Number of days of observation: Test 1, 77 days; Tests 2 and 3, 74 days each.

during the performance of the tests, uses for transpiration approximately three-fourths of the water evaporated.

Consumptive use at different stages of growth. Table 4 shows the four periods which correspond closely to the stages of growth of Milfor 6(2) and also the different rates of water used during each period. These periods were quite identical with those observed by Singh *et al.* (1935). The table also shows a comparison of the overall weekly consumptive use of water during the whole period of observation and the water used during each of the four stages.

The ratios indicate that more water was required by Milfor 6(2) during the second and third stages of growth than the overall average. While the preceding results do not agree quantitatively with those of Van de Goor (1950), they show the importance of providing adequate irrigation to meet the requirements for consumptive use and for percolation.

Evapotranspiration ratios. The relation between the amount of water used by evaporation and transpiration in producing a given crop is usually expressed by the term evapotranspiration ratio. This relation between consumptive use of water by Milfor 6(2) and yields based separately on grain and straw, and on grain-straw combina-

TABLE 3.—*Comparative values of evaporation and transpiration from the three tests*

WEEK AFTER TRANSPLANTING	CONSUMPTION USE OF WATER FROM THREE TESTS									
	Evaporation					Transpiration				
	1	2	3	Average		1	2	3	Average	
				Weekly	Daily				Weekly	Daily
3rd	2.96	3.58	2.91	3.15	0.45	1.66	(–)	(–)	0.26	0.04
4th	2.32	2.42	2.52	2.42	0.35	2.50	(–)	0.67	1.04	0.15
5th	2.32	2.51	2.77	2.53	0.29	2.63	2.01	2.52	2.39	0.34
6th	2.93	5.11	1.99	3.16	0.36	1.16	1.62	1.46	1.41	0.20
7th	2.03	2.09	1.92	2.01	0.45	2.45	0.11	0.51	1.02	0.15
8th	2.06	2.03	1.19	1.76	0.25	2.70	1.31	2.24	2.08	0.30
9th	3.33	2.18	1.50	2.34	0.33	2.39	2.20	3.28	2.62	0.37
10th	1.58	4.25	3.24	3.02	0.43	3.46	0.97	2.96	2.46	0.35
11th	1.32	1.89	1.12	1.44	0.21	0.90	1.26	2.38	1.51	0.22
12th	4.15	1.63	1.29	2.36	0.34	2.38	3.66	2.90	2.98	0.43
13th	1.87 [7a]	0.69 [4a]	0.98 [4a]	1.60	0.23	0.83 [7a]	1.29 [4a]	1.75 [4a]	2.05	0.29
Total	26.33	28.38	22.43			23.06	14.43	19.34		
Average	0.36	0.38	0.30	2.35	0.33	0.31	0.19	0.26	1.80	0.26

[a] 4, 7—Number of days included in the terminal week of observation.

$$\frac{\text{Average weekly evaporation}}{\text{Average weekly transpiration}} = \frac{2.35}{1.80} = \frac{0.33}{0.26} = 131$$

$$\frac{\text{Average weekly transpiration}}{\text{Average weekly evaporation}} = \frac{1.80}{2.35} = \frac{0.26}{0.33} = 0.76$$

TABLE 4.—*Growth stages and relation between weekly and overall average consumptive uses*

PERIOD OR STAGE	DURATION AFTER TRANSPLANTING AND CHARACTERISTICS OF STAGE	RATIO OF WEEKLY CONSUMPTIVE USE DURING STAGE TO OVERALL AVERAGE WEEKLY CONSUMPTIVE USE
1	From 3rd to 5th week Early post-transplanting and tillering	0.85
2	From the 6th to the 9th week Fast growth and early pre-boot stages	1.05
3	From the 10th to the 12th week Flowering to grain formation	1.10
4	From the 13th to draining Post-dough or maturing stage.	0.85

tion are shown in table 5. The computed evapotranspiration ratios were 1941 kilograms, 1147 kilograms, and 1721 kilograms of water

TABLE 5.—*Consumptive use and transpiration ratios, Milfor 6 (2)*

CRITERION	TEST NUMBER			AVERAGE
1. Consumptive use during period, cm.	49.39	42.20	41.77	44.45
2. Transpiration during period, cm.	23.06	14.43	19.34	18.74
3. Total consumptive use from transplanting to harvesting, kg.[a]	488.51	430.27	426.79	448.49
4. Total transpiration use from transplanting to harvesting, kg.[b]	227.45	157.55	197.32	194.11
5. Average weight of grain at 14% moisture content, kg.	0.202	0.242	0.249	0.231
6. Average weight of straw, 14% moisture content, kg.	0.449	0.301	0.424	0.391
7. Evapotranspiration or consumptive use ratio[c] based on:				
grain	2418	1778	1714	*1941*
straw	1088	1427	1007	*1147*
grain and straw	750	792	625	*721*
8. Transpiration ratio based on:				
grain	1126	651	854	*833*
straw	507	523	465	*492*
grain and straw	334	290	323	*309*

[a] Measured consumptive use, item 1 multiplied by area of tank, 8100 sq.cm., multiplied by 0.001 kg. per cu.cm. of water plus calculated consumptive uses before and after period of observation.

[b] Measured transpiration during period plus calculated transpiration before and after period of observation.

[c] Consumptive use from transplanting to harvesting (item 3) divided by weight of grain, straw or grain plus straw as the case may be.

per kilogram of dry grain, straw, and grain-straw, respectively. The transpiration ratios were 833 kilograms, 492 kilograms and 309 kilograms of water per kilogram of grain, straw, and grain-straw, respectively (table 5). These results differ to some degree from those of other similar works reported because of the difference in factors affecting consumptive use, plant growth, and yield.

Table 6 shows the average daily consumptive use of water by two varieties of rice by month during the crop seasons. With Milfor 6(2), three tests were run successively using a depth of submergence of 5 centimeters. On the other hand, three depths were tested simultaneously on Tjere Mas, using three sets of tanks. The tillering, growth, and yield characteristics of Tjere Mas were very much better than Milfor 6(2). However, because it lodges heavily especially during its heading stage, its use during the rainy season planting is rather limited.

The average daily consumptive use of water by Milfor 6(2) during the season was 0.59 centimeters and by Tjere Mas, 0.69 centimeters in 1956 and 0.88 centimeters in 1957 (table 6). The results also show the variations in the water used by Tjere Mas due to stage of growth and time of year. The depths of submergence of 5, 10, and 15 centimeters apparently did not affect the consumptive use of water by Tjere Mas.

Table 7 gives the average weather conditions prevailing during the three periods covered by the three tests in 1955. While it is true that temperature, humidity and wind velocity are the main factors affecting surface evaporation and transpiration (Grist, 1955), no serious attempt was made to study the extent to which these factors individually affect consumptive use. However, determination of the multiple correlation between the mean weekly consumptive use and weekly rainfall, relative humidity, and mean temperature prevailing during the eleven weeks of tests gave a high positive correlation of 0.607, which shows the direct relationships between consumptive use and the above climatic factors.

SUMMARY

One object of the present study was to measure the consumptive use of water by lowland rice varieties. On Milfor 6(2) and Tjere Mas consumptive use varies with the plant growth stage and development. Milfor 6(2) used daily an average of 0.59 centimeter of water in September, October, November, and December, 1955 and Tjere Mas, slightly higher, 0.69 centimeter in September, October,

and November, 1956 and 0.88 centimeter in April, May, June, July, and August, 1957. Evapotranspiration ratios based on air-dried

TABLE 6.—*Average daily consumptive use of water by Milfor 6(2) and Tjere Mas by month and under different depths of submergence irrigation in the tanks, in centimeters*

YEAR AND MONTH	DEPTH OF SUBMERGENCE	Milfor 6(2)[a] 1955	Tjere Mas[b]		
1957					
April	5		0.65		
	10		0.88		
	15		0.63	Av.	0.71
May	5		0.92		
	10		0.85		
	15		0.82	Av.	0.86
June	5		1.40		
	10		1.16		
	15		0.83	Av.	1.13
July	5		1.14		
	10		1.07		
	15		1.11	Av.	1.11
August	5		0.74		
	10		0.62		
	15		0.45	Av.	0.60
1956				Gen. av.	0.88
September	5	0.49	0.80		
	10		0.66		
	15		0.66	Av.	0.71
October	5	0.57	0.64		
	10		0.62		
	15		0.85	Av.	0.70
November	5	0.66	0.64		
	10		0.66		
	15		0.64	Av.	0.65
December	5	0.57			
	10				
	15			Gen. av.	0.69

Total depth for season—45.53

1956
5 cm. deep— 86.39
10 cm. deep— 84.59
15 cm. deep— 93.87
1957
5 cm. deep—104.29
10 cm. deep—101.95
15 cm. deep— 96.01

[a] Average for three tests, one depth.
[b] Average for one test per depth.

TABLE 7.—*Weekly consumptive use, evaporation and transpiration, weekly rainfall, mean relative humidity and daily temperature*

WEEK AFTER TRANSPLANTING	Consumptive use	Evaporation	Transpiration	Rainfall	Relative humidity (Daily)	Temperature (Daily)
	cm.	*cm.*	*cm.*	*cm.*	*per cent*	*°C.*
3rd	3.41	3.15	0.26	2.57	74.2	28.2
4th	3.46	2.42	1.04	2.81	75.3	27.4
5th	3.95	2.53	1.41	3.98	82.7	26.9
6th	4.19	3.16	1.02	2.51	75.9	26.9
7th	4.40	2.01	2.39	3.09	76.3	27.7
8th	3.84	1.76	2.08	4.54	75.6	29.1
9th	4.96	2.34	2.62	1.99	82.4	27.0
10th	5.49	3.02	2.46	7.34	76.1	26.7
11th	2.96	1.44	1.51	4.44	81.9	25.3
12th	5.34	2.36	2.98	20.53	77.2	24.8
13th	3.53	1.60	2.05	2.01	78.5	25.7
Total	45.53	25.79	19.82	55.81	856.1	295.7
Average	4.15	2.35	1.80	5.1	76.9	27.1

grain, straw, and grain plus straw for Milfor 6(2) were 1941, 1147 and 721, respectively. The transpiration ratios for Milfor 6(2) on the same bases were 833, 492 and 309.

LITERATURE CITED

AGLIBUT, A. P. and P. R. HOFF. 1956. Effects of continuous and discontinuous submergence on rice lodging and yield. Philippine Agriculturist **40**: 453-464.

ALFONSO, DOMINGO and A. B. CATAMBAY. 1948. A study of the net duty of irrigation water for lowland rice in Calamba, Laguna. Philippine Agriculturist **32**: 87-113.

BORJA, V., J. P. TORRES and F. P. OCTUBRE. 1952. Fifty years of rice research. A Half-century of Philippine Agriculture. xiv + 403. Manila. Bureau of Plant Industry.

COPELAND, E. B. 1924. Rice. xiv + 352 pp. London: MacMillan & Co., Limited.

GOOR, G. A. W. VAN DE. 1950. Research on Rice Irrigation. General Agricultural Research Station Contribution No. 112, Bogor, Indonesia, pp. 1-34.

GORDON, ALEXANDER. 1929. A summary of studies on the depth of irrigation water for lowland rice for Western Laguna. Philippine Agriculturist **17**: 579-593.

GRIST, D. H. 1953. Rice. xix + 331 pp. London, New York & Toronto: Longmans, Green and Co.

JONES, J. W. 1933. Effect of depth of submergence on the control of barnyard grass and yield of rice grown in pots. Jour. Amer. Soc. Agron. **25**: 578-583.

MAYUGA, RICARDO. 1955. The growing concern for communal irrigation. Golden Book, B. P. W., Department of Public Works and Communication, pp. 29-32.

MORRISON, S. T. 1953. Rice irrigation tests at the Beaumont Station. 1952. Progress Report. Texas Agric. Expt. Sta.

SATO, KENKICHO. 1954. Measuring method of the net duty of irrigation water for the paddy field. Proceedings of the Food and Agriculture Organization of the United Nations, IRC Working Party on Rice Breeding, Tokyo, Japan, Oct. 4-10.

SEN, P. K. 1937. Studies on the water relations of rice. I. Effect of watering on rate of growth and yield of four rice varieties. Indian Jour. Agric. Sci. **7**: 89-117.

SINGH, B. N., K. B. SINGH, and K. SINGH. 1935. Investigations into the water requirement of crop plants. Proc. Indian Acad. Sci. Sect. B. **1**: 471-495.

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